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Nuclear Power

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REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · ATION

Utilities 44·1%

Production of heavy water in the U.S.A. . . . page 108

Administration 27·1%

Also in this issue

HTGR design problems

Labour 19·5%

February 1960 monthly 3/6

Materials 9·30%

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Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION

VOL 5 NO 46 FEBRUARY 1960

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SPECIAL FEATURES

Production of heavy water in the USA
V. R. Thayer, Director of Du Pont's chemical process section, describes the company's experience in developing, building and operating two full-scale heavy water plants for the AEC 108

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Due critical in 1963, the design of the OEEC 20 MW reactor experiment is well advanced. G. E. Lockett and R. A. U. Huddle review development of the design and summarize present proposals 112

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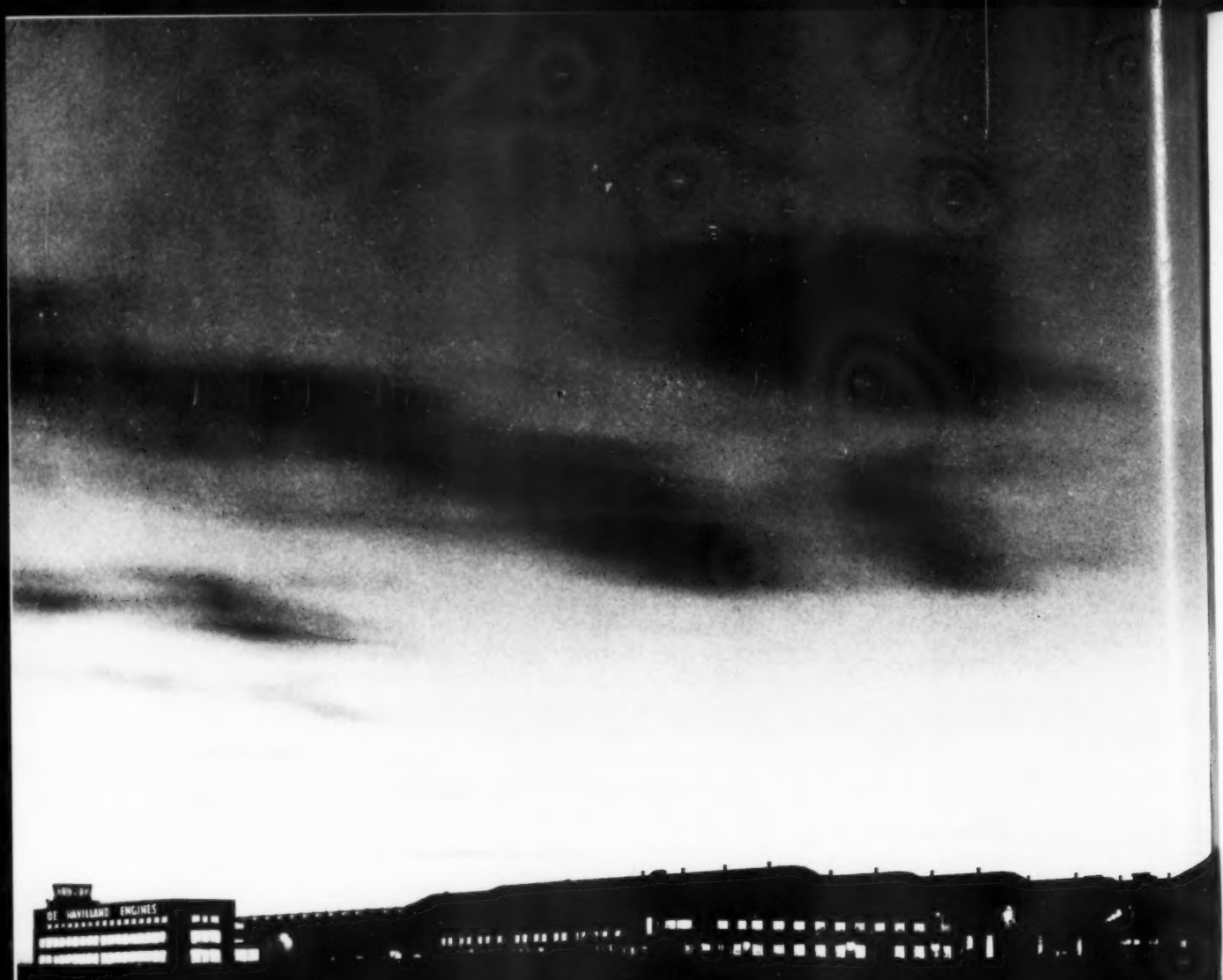

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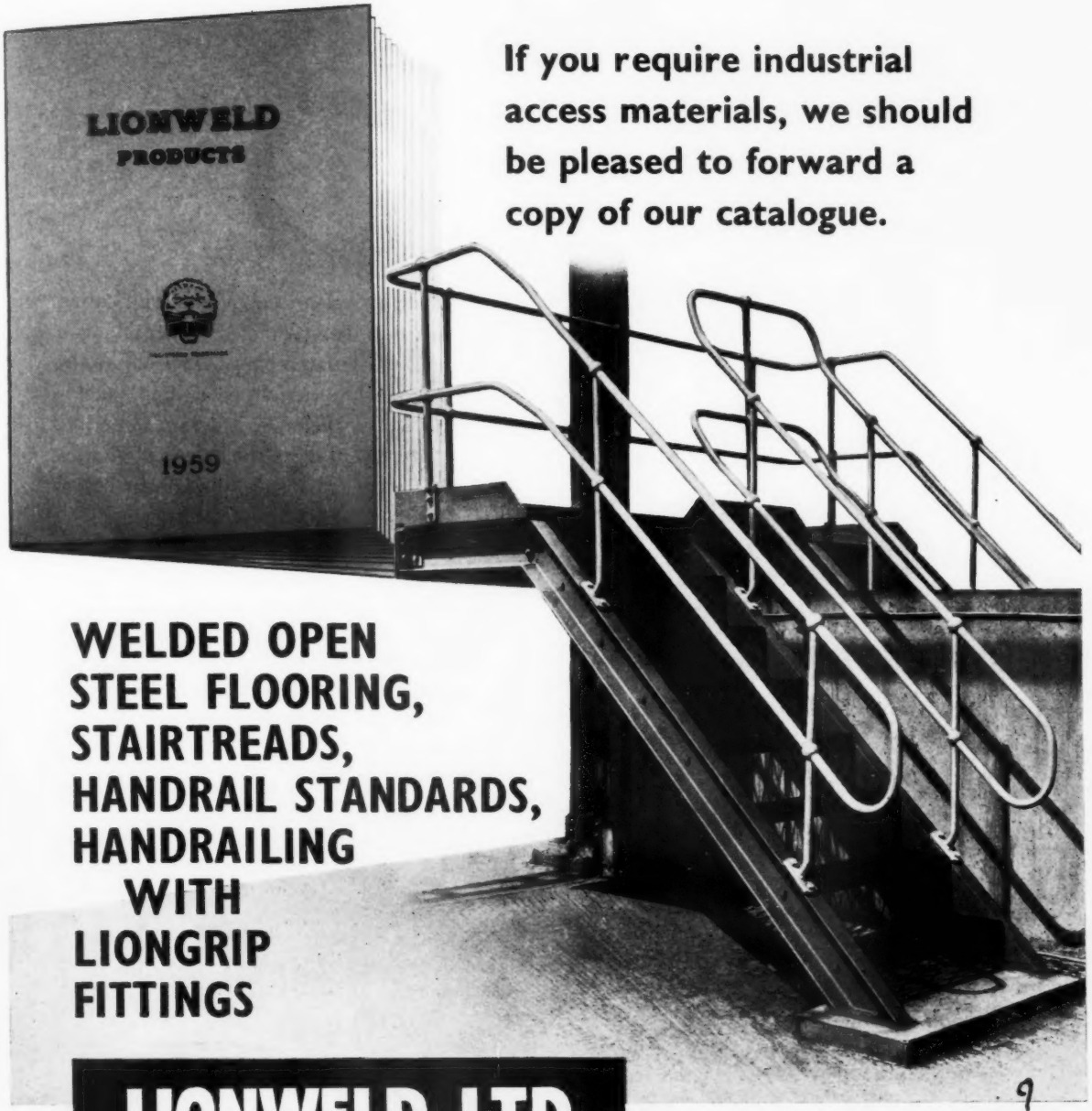

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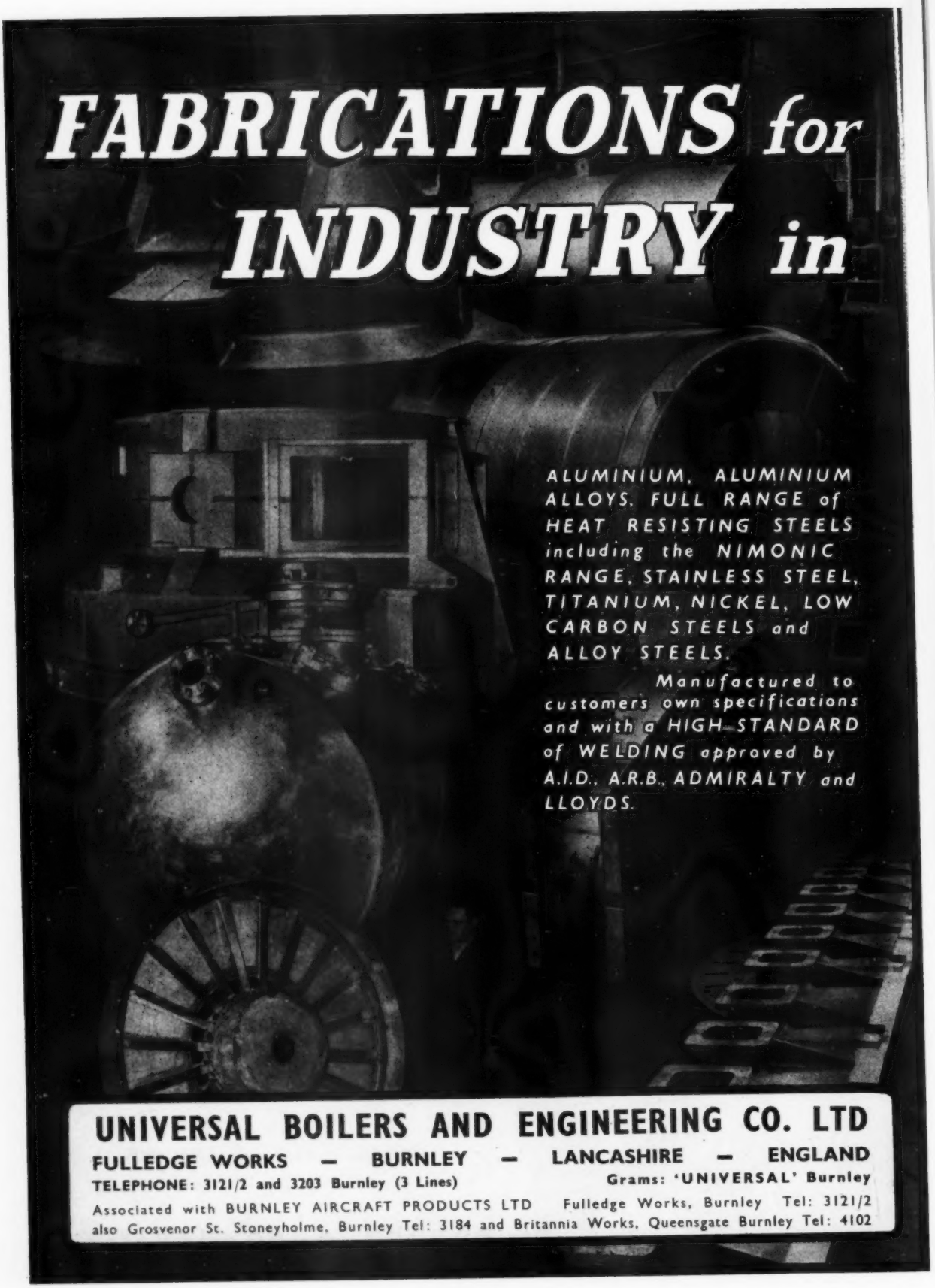

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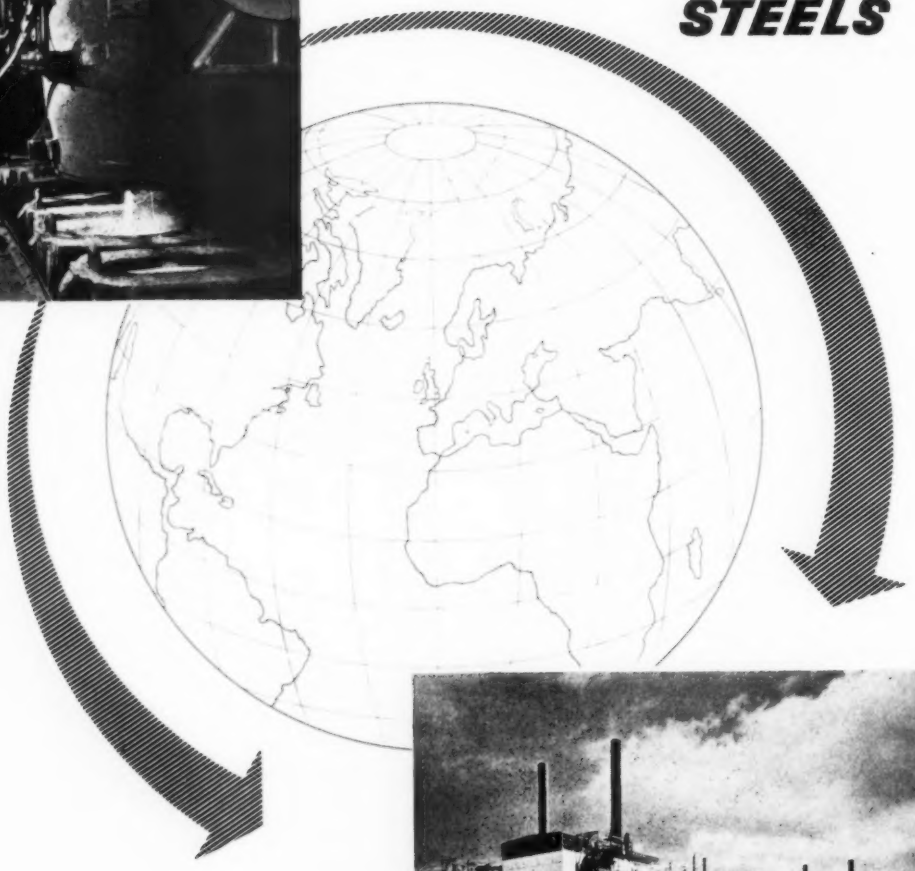

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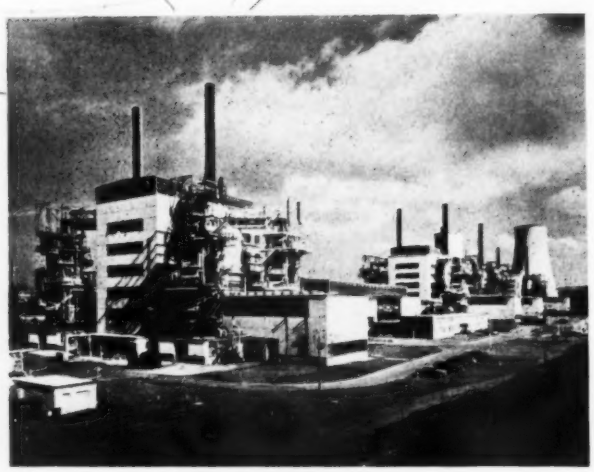

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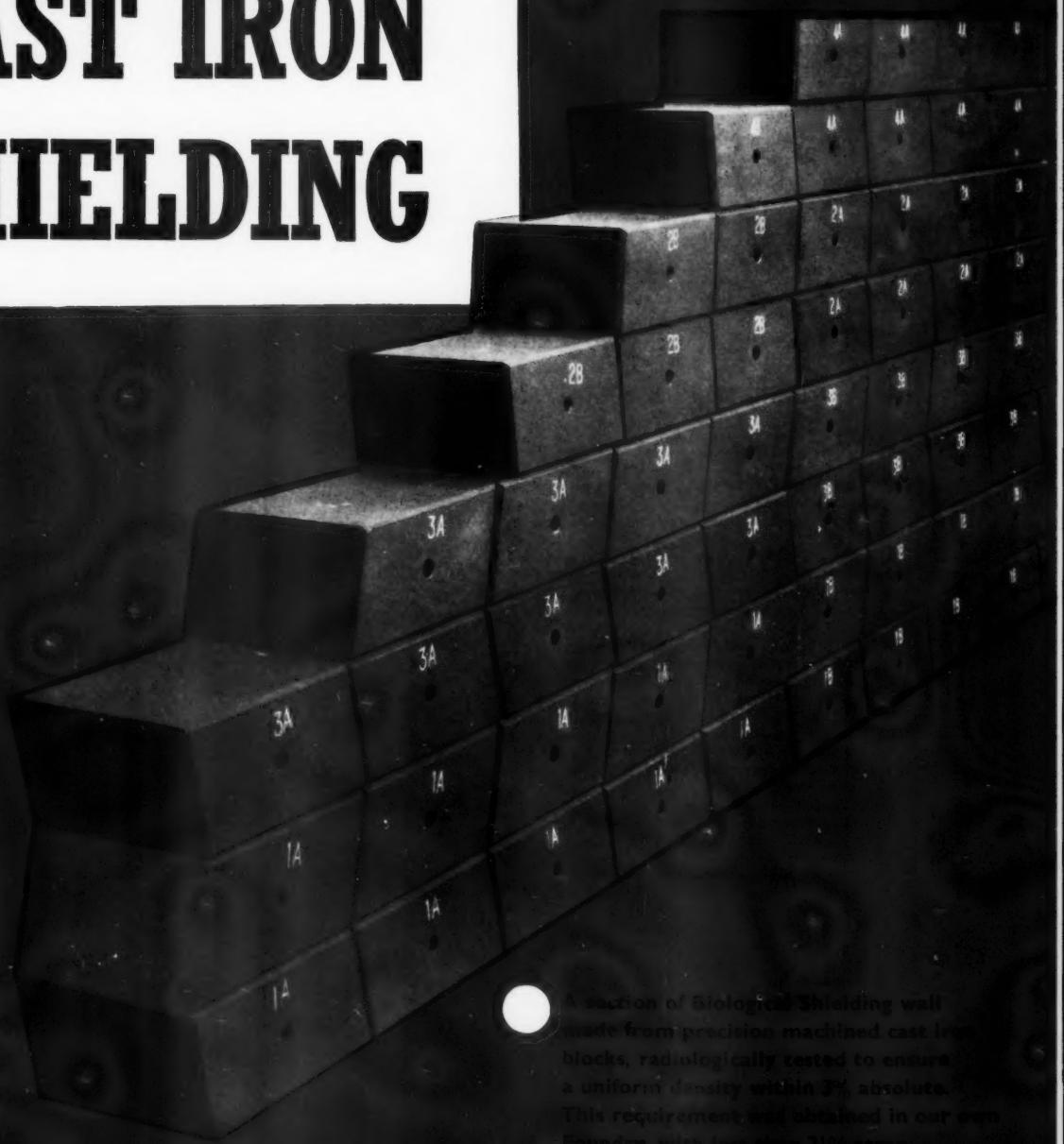

A section of Biological Shielding wall made from precision machined cast iron blocks, radiologically tested to ensure a uniform density within 2% absolute. This requirement was obtained in our own Foundry, with less than 2½% scrap.

Typical sample of shielding delivered to Harwell and Dounreay as a sub-contract order from Head Wrightson Processes Ltd.

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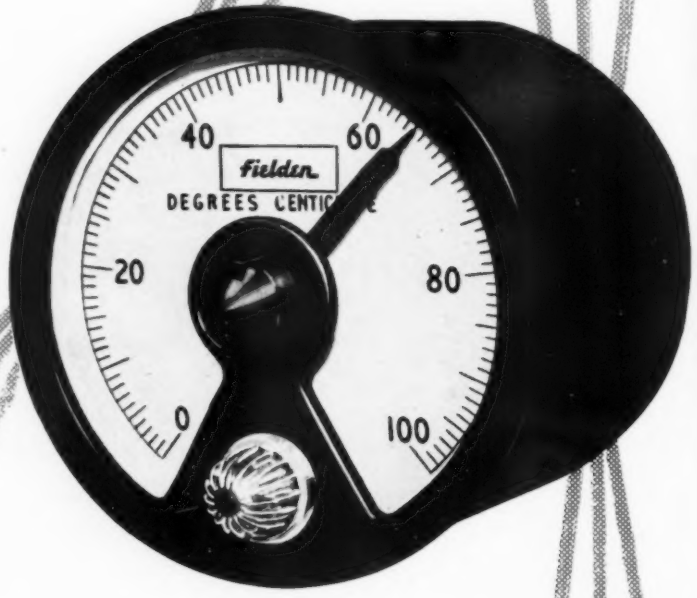

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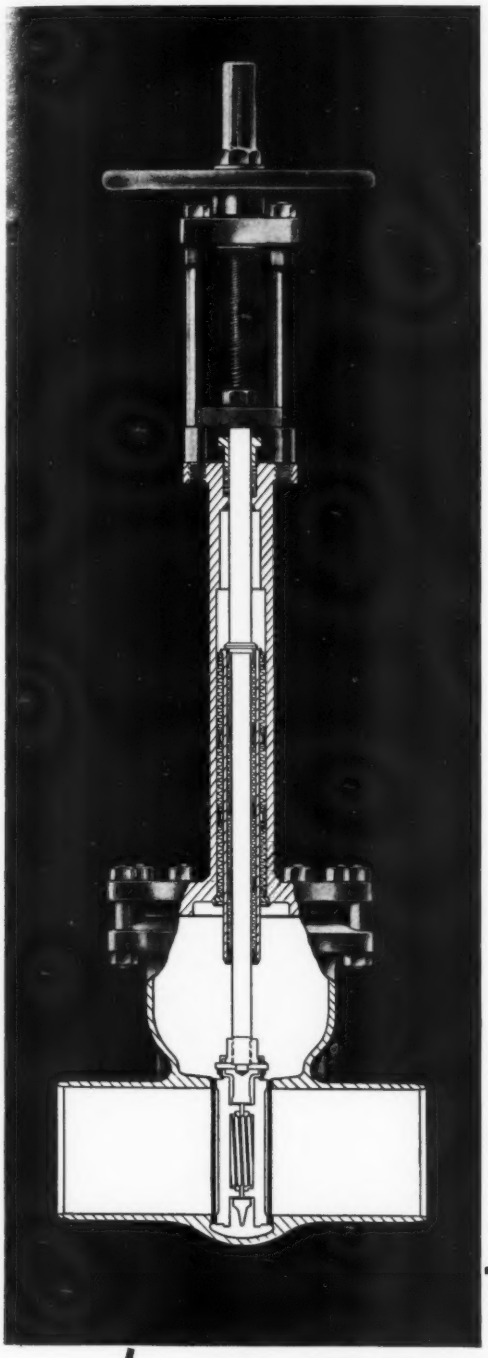

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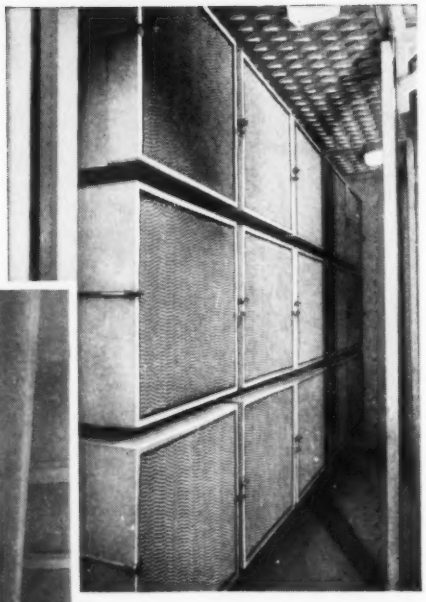
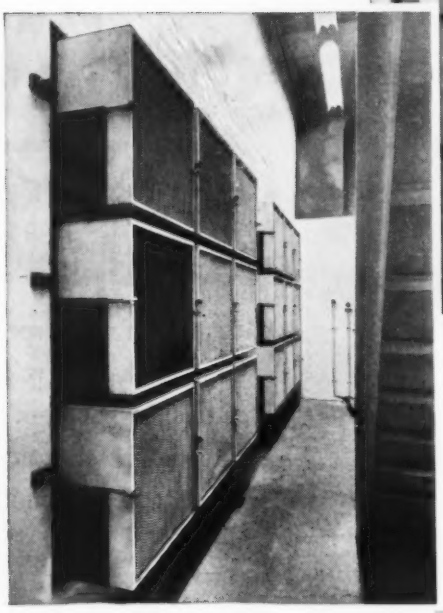
Vokes at Harwell

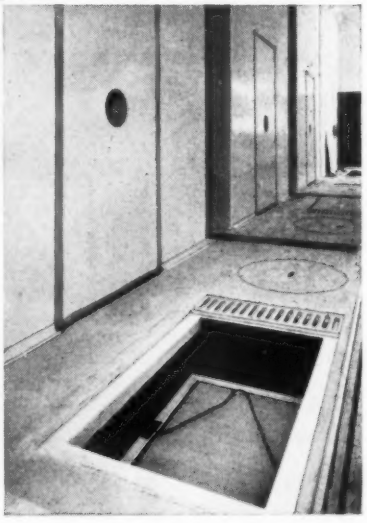




Vokes 44 'Absolute' filters on the intake side.

Vokes 55 'Absolute' filters on the extract side.

A Vokes 55 'Absolute' under-floor cell filter in the operating area.



In the High Activity Materials Handling Building at Harwell, Vokes 'Absolute' filters were specified by the Ministry of Works for the ventilation plant. Already in use at Aldermaston and Dounreay Vokes 'Absolute' filters provide the highest standard of filtration at present available — 99·95% tested efficiency against a methylene-blue dust cloud. Each filter is tested before despatch and is unreservedly guaranteed. Vokes 'Absolute' filters, and other Vokes types, are playing and will continue to play a vital part in Britain's nuclear power programme. Our engineers will be glad to give you full details of the Vokes 'Absolute' filter.

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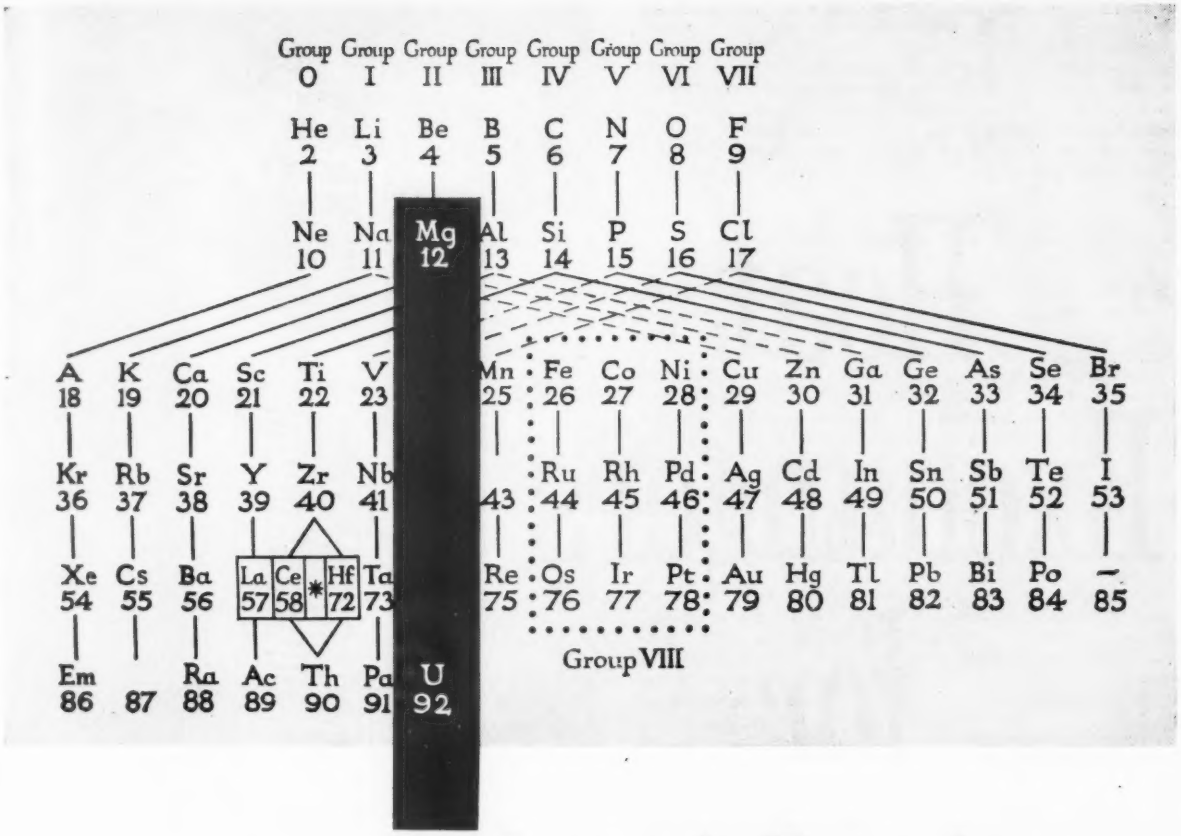
V313



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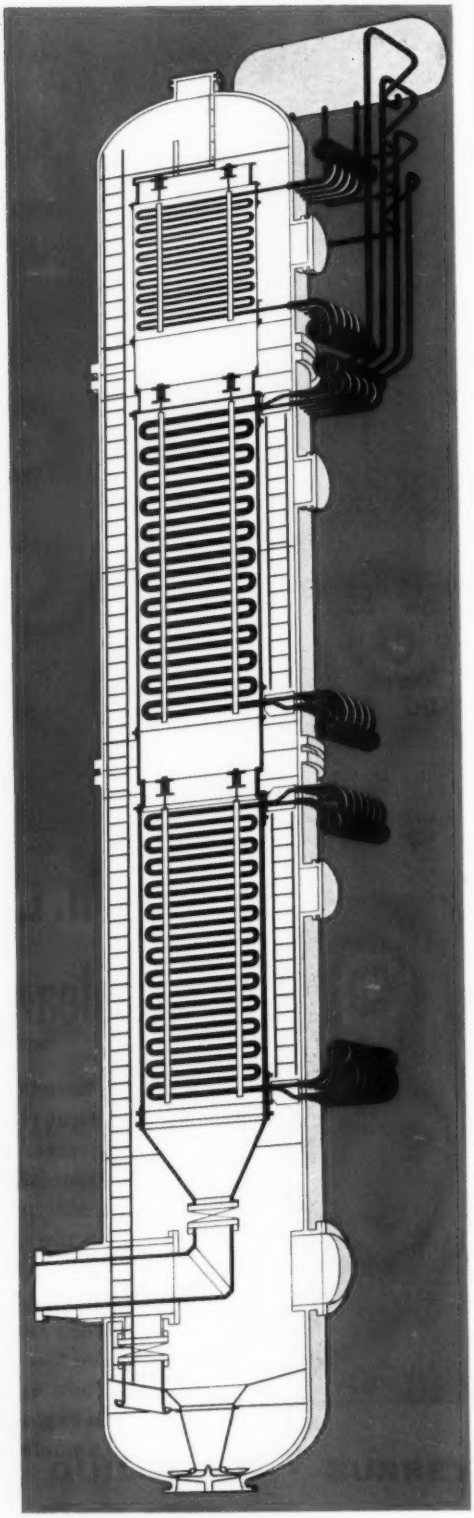
Heat Exchangers for Windscale



One of the significant contracts being undertaken by International Combustion (Nuclear Applications) Limited is the supply of heat exchangers for the Advanced Gas Cooled Reactor at the Atomic Energy Authority's plant at Windscale. The design, development and manufacture of such equipment is in the hands of highly skilled International Combustion engineers at Derby, where adequate facilities exist for the application of the latest welding and manufacturing techniques involved in work of this type.

A sectional model of one of the heat exchangers for the Atomic Energy Authority's plant at Windscale

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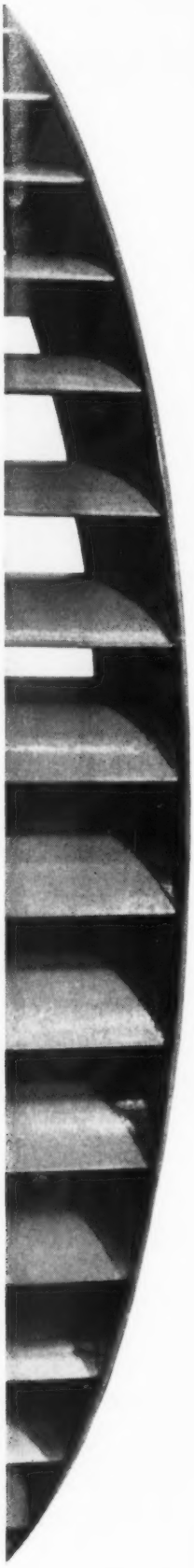
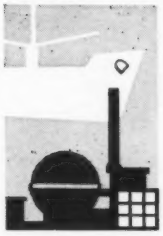


formula for leadership



Experience Founded originally in 1823 the Company has had the widest experience in the design and manufacture of all types of equipment for the handling of air and other gases. Blowers, exhausters, heaters, filters, dust and fume removal equipment, and of course, fans of all types, fall within this wide scope. Fans of every size and for every purpose, from Coal Mines to Aircraft Carriers, have been designed, manufactured and tested by Keith Blackman and installed in all parts of the world—experience unparalleled in the field.

Range The Keith Blackman range covers virtually every type of fan and blower in all sizes—axial types from 5 inch to 100 inch diameter, centrifugal types ranging from 1½ inch to 180 inch, and propeller fans from 6 inch to 72 inch diameter. Many are designed for special applications and in special materials including pvc. Other equipment is made for heating, cooling, washing, dust and fume extraction, filtration and air conditioning. *Five thousand fans of varying types are kept continuously in stock for quick delivery.*

Research Keith Blackman's lead in design is maintained by five separate research departments. Specialised facilities are available at Tottenham for the development and testing of axial fans, centrifugal fans and filtration equipment, while a metallurgical laboratory controls the quality of materials founded at Arbroath. Tottenham also possesses one of the most advanced acoustics laboratories in the world for the investigation of sound levels in all types of fan engineering equipment.
In addition, the company's generating station, as well as supplying power to the factory, is designed to produce a wide range of A.C. and D.C. supplies for the test beds.

Keith Blackman Ltd
(incorporating Blackman Export Co. Ltd.)
MILL MEAD ROAD, LONDON N.17 TOTTENHAM 4522

Leaders in the Fan Industry

Resources The company's three factories cover an area of 17½ acres, and employ over 1,800 people. The main Tottenham works produces small and medium units and includes drawing offices, test facilities and machine shops, as well as the sales and administration offices.
The Arbroath works deals with the production of the larger fans. Its iron and non-ferrous foundry plant supplies the whole of the company's casting needs.
The Edmonton Factory concentrates on light sheet metal and plate work and the fabrication of steel structures.
Virtually all components, including fan motors and bearing housings, are thus designed and manufactured within the organisation—a unique combination of resources.

Service Through the years the company has built up an enviable reputation for service at all stages. Sales representatives are all fully trained technical men capable of giving 'on the spot' advice on routine applications or special problems. The sales organisation operates from branches throughout the country backed by a staff of qualified sales engineers at Head Office.
Despatch of stock items, of which 5,000 units are kept continuously available, is possible in as little as four days. The Company has its own road transport fleet and direct rail connections from the main factory.

TM.245/1044

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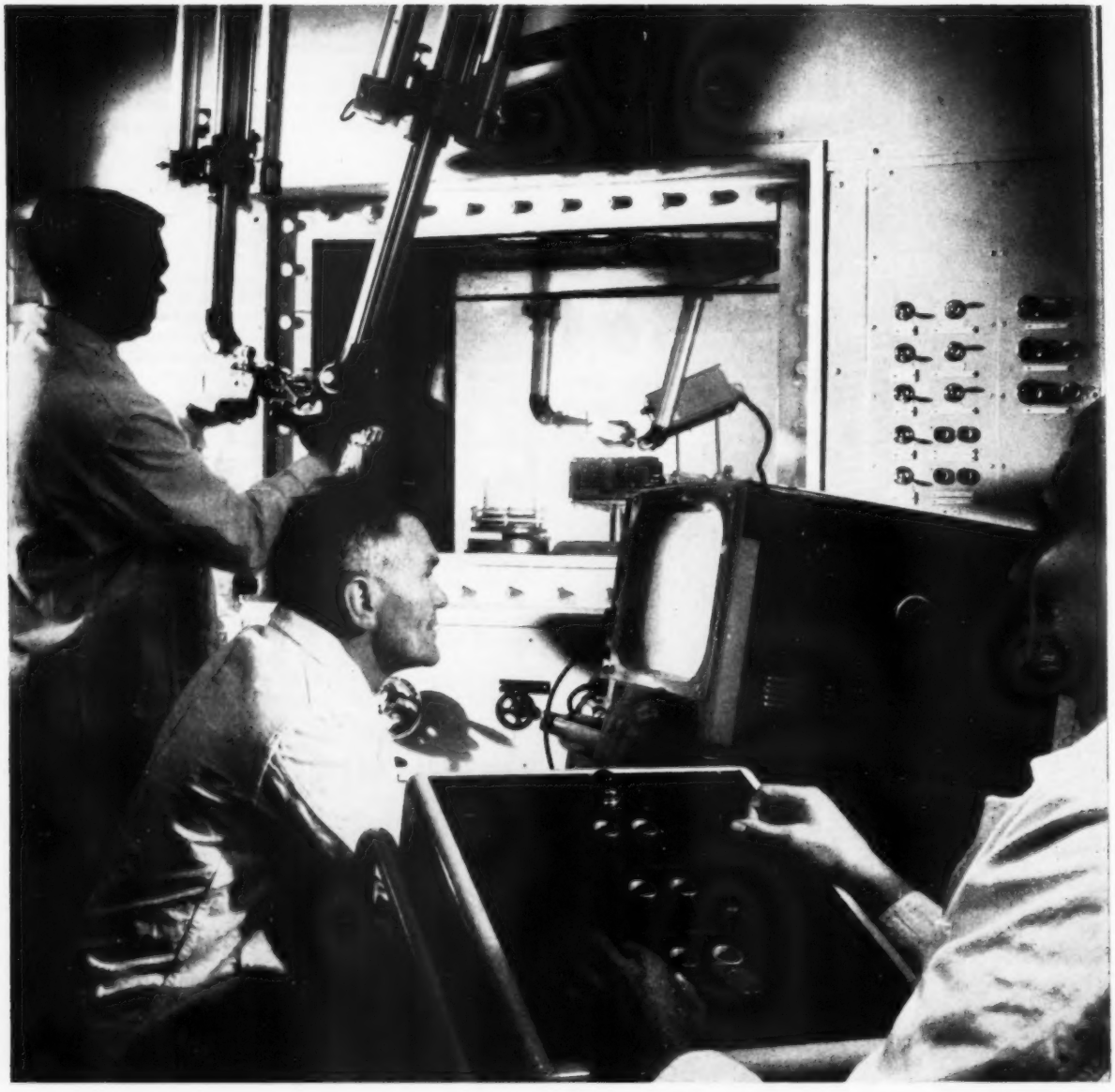

Pye at Dounreay

The Pye Instrument Group has supplied all the equipment to the U.K. Atomic Energy Authority for the irradiated fuel element laboratory at Dounreay. In addition to supplying equipment, Pye Ltd. acted as consultants and designers on all matters in that laboratory relating to instrumentation and remote handling. The illustration above shows manipulators working in conjunction with a television camera to handle and measure a sample from the fast reactor.

The Pye Instrument Group consists of : Pye Atomics Division ; Pye Industrial Television Division ; Faraday Electronic Instruments Ltd.; Labgear Ltd.; W. G. Pye & Co. Ltd.; Pye Telecommunications Ltd.; Unicam Instruments Ltd.; W. Bryan Savage Ltd.; W. Watson & Sons Ltd.

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As forged and heat treated 101" o/d, 65" i/d, overall width 27" (by courtesy of Whessoe Ltd.)

As machined prior to installation for 3' 3" bore inlet duct and duct erection opening for heat exchangers (by courtesy of International Combustion Group)

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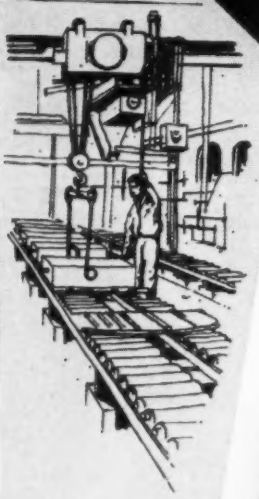
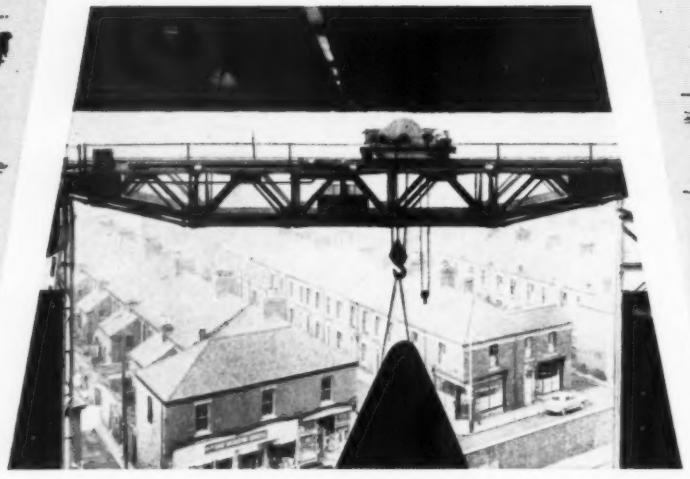
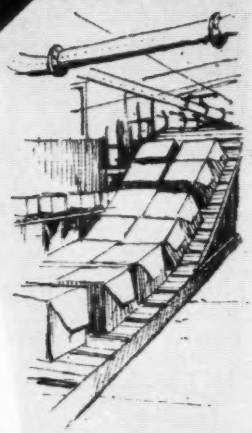
PATERSON HUGHES
ENGINEERING COMPANY LIMITED





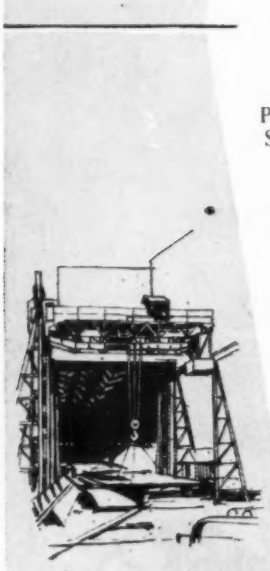


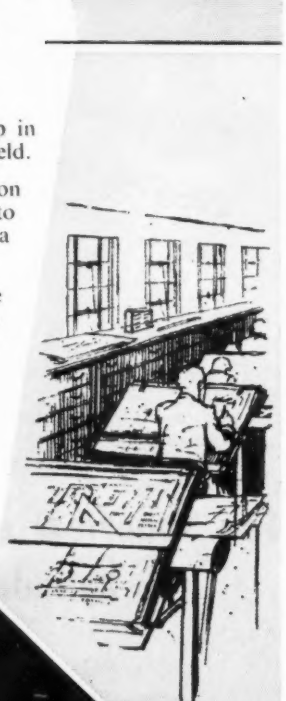
A Paterson Hughes 30-ton electric overhead travelling crane at Blyth Dry Dock and Shipbuilding Co. Ltd.—by whose courtesy this photograph is reproduced.

Paterson Hughes cranes are built in their modern crane shop in Scotland to designs based on their 35 years of experience in this field.

If the Paterson Hughes range—from hand jibs to 100-ton overhead cranes—does not include a standard model suited to your exact needs, then a special will be designed at a competitive price.

Paterson Hughes engineers will also design complete crane systems, extending from your goods inwards bay to the finished products warehouse, bearing in mind the special requirements of each industry.





THE PATERSON HUGHES

CRANE DIVISION

Specialists in modern crane practice

BIRMINGHAM
3 Highfield Road
Edgbaston Birmingham 15
Phone: Edgbaston 2957-8

GLASGOW
Wyndford Works
Maryhill Glasgow
Phone: Maryhill 2172-4

SOUTH AFRICA—Paterson Hughes Engineering SA (PTY) Ltd PO Box 811 Johannesburg

LONDON—Bedford House Bedford Street London WC2 Phone: Temple Bar 7274-6

P.2114

EKCO Thermocouple Trip Amplifier

SPECIFICATION

Operational Trip Setting. 0-600°C.

Trip Margin Meter Indication. 50°C. below trip.

'Low-Margin' Trip. May be set anywhere within the available trip margin range.

Trip-Accuracy. 0.4% of trip temperature.

'Low-Margin' Trip Accuracy. Better than 2% of the meter range. (Accuracy limited because the meter is used for setting).

Hysteresis and Stability of Both Trips. 2% of meter range.

External Facilities. The warning and trip relays each provide the following facilities which are connected to plugs at the rear of the instrument:—two sets of change-over contacts and two short circuit pairs.

Input Signal Required. 40 μV/°C.

Thermocouple Earthing. Can be at either terminal or at the hot point. (The amplifier is isolated from earth).

Stability. Cold junction compensation ensures that performance remains within the limits specified up to 40°C. ambient temperature. Performance is unaffected by mains variations of +8% —20%.

Thermocouple Resistance. Up to 250 ohms for performance specified. Up to 500 ohms for ambient temperature ('cold junction') up to 30°C.

Response Time. Less than 0.2 seconds.

Recorder Output. A 100 mV recorder can be driven to indicate the meter reading at an impedance of 100 ohms.

Dimensions. Front panel 4″ wide x 8¾″ high. Depth 13″.

Mains Input. 110-120v or 200-250v A.C., 45/60 c/s.

Mains Consumption. 20 watts approximately.

N642A

Illustration shows special version with 0-250° range.

The Ekco range of reactor instruments also includes the following:—

Reactor Period Meters with alternative ranges.
Reactor Power Error Meter.
Resistance Thermometer Trip Unit.
Shut-Down Amplifier (with start-up facilities and shut-down state trip).
Fast Neutron Monitor (installed).
Misalignment Indicator (for coarse control arms.)
Leak Indicator (for external heavy water leak).
Effluent Monitor.
Battery Box Assemblies.
Logarithmic Gamma Health Monitor (installed).
Slow Neutron Survey Meter (portable).
Beta-gamma Survey Meters (portable).
Decade Voltage and Current Generator (general purpose test unit).
Reactor Period Meter Test Unit.

EKCO ELECTRONICS LIMITED

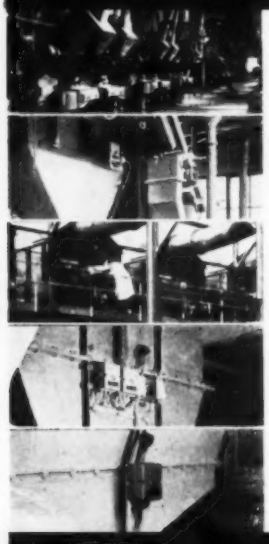
Sales, Installation and Service

SOUTHEND-ON-SEA · ESSEX · Telephone: Southend 49491

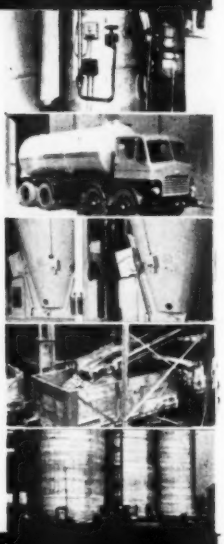
Tick **No 21** on reply card for further details

Whatever your level problem

Wherever your level problem



Coal and Coke	Tanks
Sugar	Tankers
Water	Hoppers
Cement	Conveyors
Food, etc.	Silos, etc.



The Fielden *CAPACITANCE METHOD* is the simplest answer

The principle of capacitance control and indication of level for industrial purposes has been successfully used by Fielden Electronics Ltd. for the past ten years. In that time it has produced a range of instruments used throughout the world to answer almost every level problem involving any liquid or free-flowing solid regardless of conductivity, insulating value, density or corrosive properties. Installation is simple, there are no moving parts in the container and direct contact with the material is unnecessary.

Send for fully illustrated literature.

The range includes the famous

TEKTOR Regd.
Level Controller

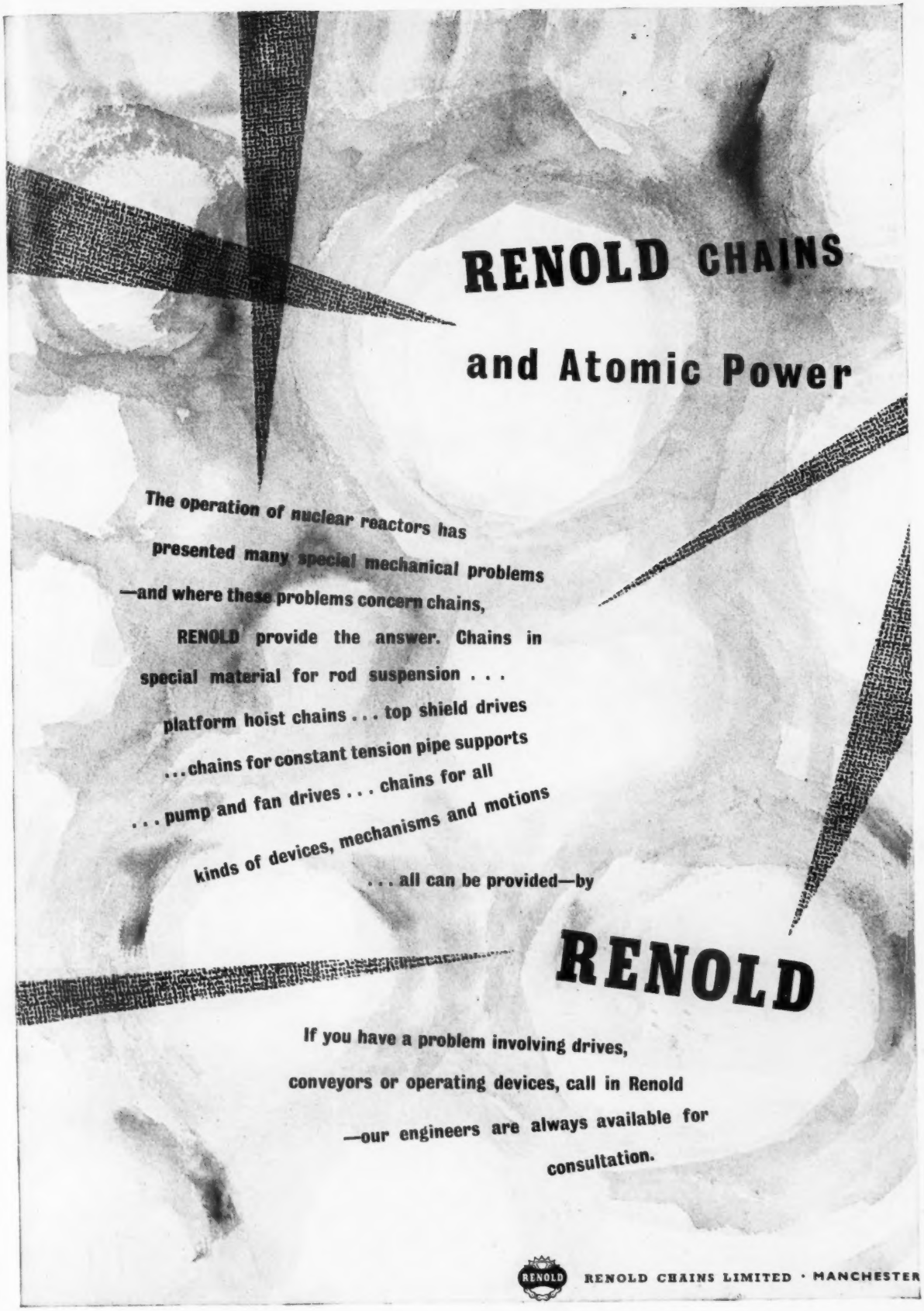
TELSTOR Regd.
Level Indicator

Fielden

FIRST IN LEVEL

INDICATING
RECORDING
CONTROL

FIELDEN ELECTRONICS LTD., WYTHENSHAWE, MANCHESTER Phone: Wythenshawe 3251 (4 lines) Grams: Humidity Manchester
ALSO AUSTRALIA, ITALY AND CANADA. *Branch Offices:* LONDON, WALSALL, STOCKTON-ON-TEES, EDINBURGH, DUBLIN
TT2


RENOLD CHAINS
and Atomic Power
The operation of nuclear reactors has presented many special mechanical problems —and where these problems concern chains, RENOLD provide the answer. Chains in special material for rod suspension . . . platform hoist chains . . . top shield drives . . . chains for constant tension pipe supports . . . pump and fan drives . . . chains for all kinds of devices, mechanisms and motions . . . all can be provided—by
RENOLD
If you have a problem involving drives, conveyors or operating devices, call in Renold —our engineers are always available for consultation.
RENOLD
RENOLD CHAINS LIMITED · MANCHESTER

Mr. Philpot is scarcely old, but he's certainly getting on

Round about thirty, they say, is the best age for thinking and building careers.

In our experience this does not noticeably depress the more mature. They direct projects, manage businesses, contribute both to fundamental and applied science and successfully spoil their families.

One thing we are certain about—the regular subscribers to this magazine include a very high proportion of those who have 'arrived' or are about to. *Nuclear Power* is a unique source of specialized information, and no-one can get on without that.

There is a pre-paid subscription card facing page 196.

AIRMEC INSTRUMENTATION

keeps in step with nucleonic needs

MONITORS

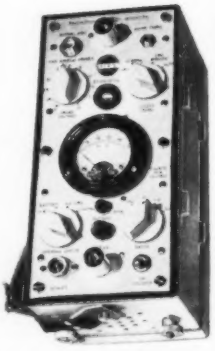
RADIATION MONITOR *Type 1021 B*

- ★ **SAFEGUARDS against contamination.**
- ★ **TRACES radio-active material in chemical analytic processes.**
- ★ **MEASURES contamination of any resulting effluent.**

Designed in conjunction with A.E.R.E. Harwell, this instrument is probably the most widely used general purpose monitor in the world. It has been PROVED by years of user experience to be the most accurate and reliable equipment of its type.

The Radiation Monitor consists of a mains operated Indicator Unit together with a Beta Gamma or Alpha Probe Unit. Indication is provided visually by means of a meter which is calibrated in counts per second, and audibly by means of a loudspeaker. A socket on the front panel is also provided to enable the output to be fed to a scaling unit.

Write for descriptive leaflet No. 26D giving full details.



RADIATION MONITOR *Type 255*

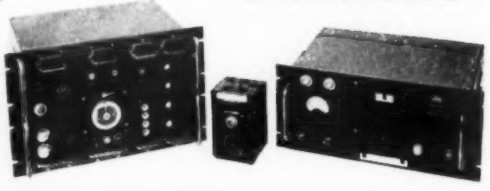
- ★ **Transistorised, battery operated, portable.**
- ★ **Laboratory accuracy under field conditions.**
- ★ **Wide range of probes and accessories available.**

Airmec are proud to be the first to announce a fully transistorised monitor which combines laboratory accuracy with complete portability. The uses include:

1. Checking the presence and amount of radio-active contamination in laboratories and workshops.
2. Checking atmosphere 'fall-out' and contamination of food, animals, crops, milk and water supplies, etc.
3. Following the progress of radio-active tracer elements in medical, geological, agricultural and industrial processes.
4. Tracing the whereabouts of radio-active areas and making accurate assays of samples in geological surveys.
5. Tracing lost samples of radio-active materials both in buildings and out.

Write for descriptive leaflet No. 177

SCALERS



GENERAL PURPOSE COUNTER *Type 1339 A*

- ★ **Designed and developed in conjunction with U.K.A.E.R.E.**
- ★ **Provides comprehensive scaling facilities for all types of Geiger Scintillation Counters.**
- ★ **Incorporates stabilised E.H.T. supplies.**
- ★ **Fitted with automatic timing control.**

This equipment is built on a unit basis and provides very comprehensive scaling facilities for all types of accurate assay work. It consists of two main units — a Power Unit and a Scaling Unit — together with a number of optional sub-units. These include a Quenching Unit, a High Speed Scaling Unit, an Amplifier/Discriminator Unit, a Paralysis Unit and a Timing Unit.

Full details are given in descriptive leaflet No. 185

Airmec

INSTRUMENTS FOR THE NUCLEONIC INDUSTRY

AIRMEC LIMITED · HIGH WYCOMBE BUCKS

Telephone : High Wycombe 2060

Full protection . . .

The advance of nuclear atomic energy technology has brought with it improvement of design and application of radiation shielding windows constructed by Chance-Pilkington.

Each particular requirement needs the benefit of specialised design experience which will ensure the highest possible efficiency at the lowest cost, and in this respect it is desirable to have the windows custom built to obtain the maximum advantages.

Chance-Pilkington allow for maximum flexibility in design and construction of windows by providing glasses in stabilised and unstabilised form in densities 2.5 gm/cc, 3.3 gm/cc, 4.3 gm/cc and 6.1 gm/cc. These glasses can be supplied in forms from raw unpolished glass to the complete windows ready for installation.

Our free advisory and design service would welcome the opportunity of considering your own requirements.

Shielding Window Advisory & Design Service,

Chance-Pilkington
Optical Works

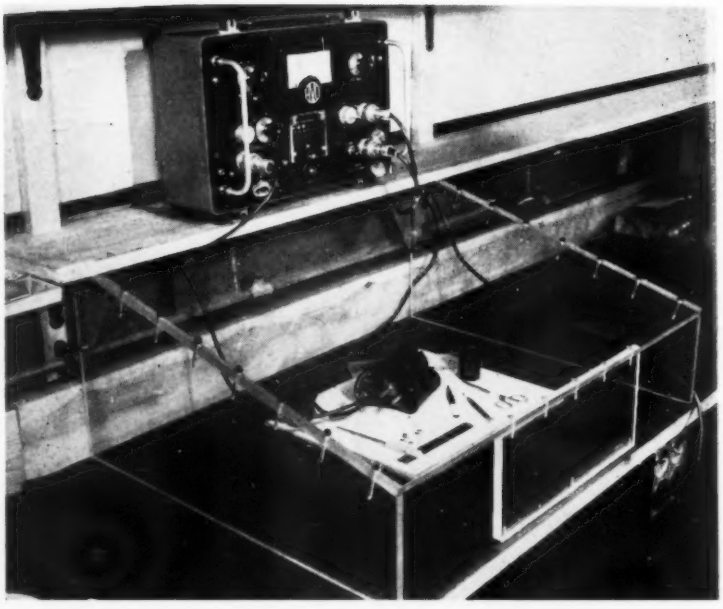
St. Asaph · Flintshire

Tick No 27 on reply card for further details

AVO in action . . .

The photograph shows an AVO "D.C." Amplifier Type 1388 being used to measure current of the order of 10^{-13} A in the ionisation chamber of an "Avo" Radiac Survey Meter. A radio-active source is being used to calibrate the instrument and a Perspex screen is employed to protect personnel from Beta radiation.

This is a typical example of how the AVO organisation, working in conjunction with Government research authorities, continues to make its contribution in the fields of modern scientific development and industrial progress.



AVO Instruments :—

Model 8 AvoMeter	Model 7 AvoMeter Mk. II
Model 40 AvoMeter Mk. II	Heavy Duty AvoMeter Mk. V
Panclimatic AvoMeters	Signal Generators
Electronic Test Meters	Electronic Test Unit
Valve Tester Type 160	Valve Characteristic Meter Mk. III
Universal Measuring Bridge Type 1	Electronic Multimeter Type 38
D.C. Amplifier Type 1388	Radiac survey Meters

etc., etc.

A fully descriptive Brochure is available on request for each of the Avo Instruments listed above.

AVO Ltd. AVOCET HOUSE · 92-96 VAUXHALL BRIDGE RD. · LONDON · S.W.1

Telephone: VIC 3404 (12 lines)

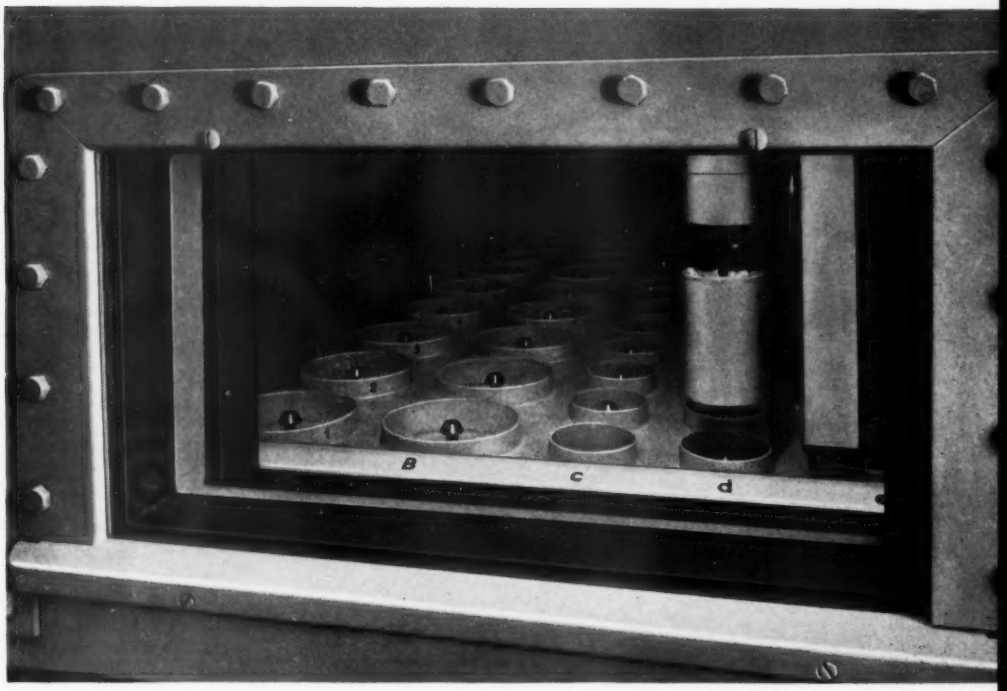
Manufacturers of ELECTRICAL, ELECTRONIC & NUCLEONIC INSTRUMENTS and DOUGLAS & MACADIE COIL WINDING MACHINES

A MEMBER OF THE METAL INDUSTRIES GROUP OF COMPANIES

PROTECTIVE GLASSES

against Radio-active Radiation

There are 10 types available with varying lead content and in densities from 2.53 to 6.20. Among those there are also several stabilized types which will not become brown even under exposure to high radiation doses. The great number of glass types permits good adaptation of the thickness of the windows to that of the protective walls. Depending on glass type it is possible to produce blocks in sizes up to 1,3 m at thicknesses from 15 to 30 cm.



For further use in nuclear research we supply

Bubble Chamber Windows
made of best optical glass in untempered and tempered quality. Even large windows can be tempered.

Cylindrical Blocks of Lead Glass for Cerenkov-Counters
of high refractive optical glasses, especially free from colour.

SCHOTT & GEN MAINZ

JENA[ER] GLAS

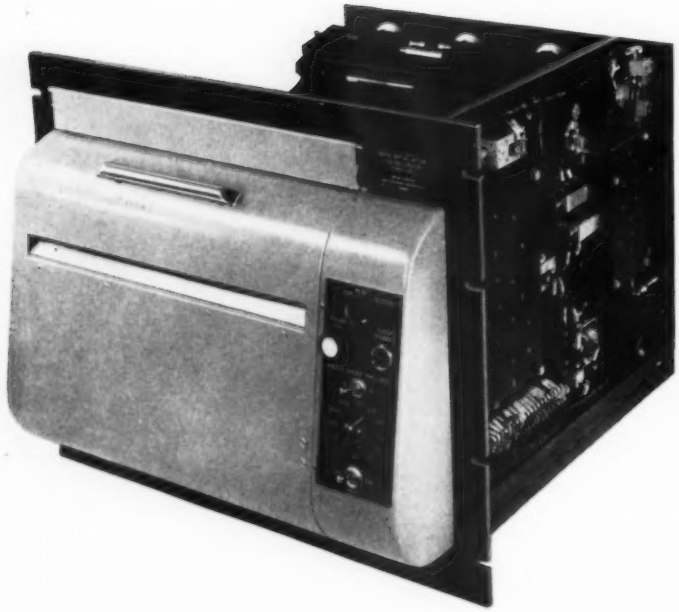
JENA[ER] GLASWERK SCHOTT & GEN., MAINZ

Western Germany

Tick **No 29** on reply card for further details

the latest NEP recorder offers:

Ultra Violet Recorder Type 1185



- Direct writing but with galvanometer sensitivity and frequency response
- **Up to 36 recording channels**
- 21 paper speeds 0·05″/sec. to 120″/sec. (all selectable by electrical switch – or remote operation)
- 5 speed timer (speeds automatically selected). Timing lines across full width of paper
- Recording paper any width up to 12″; capacity 200 ft
- Trace identification, six datum lines and event channel are standard fitments
- Recording frequencies D.C. to 5000 c/s
- Deflections up to 12″ with our low frequency galvanometer
- Direct recording from thermocouples and strain gauges is possible without amplifiers, up to 250 c/s
- Dimensions only 19″ × 16″ × 17″

Some representative galvanometer sensitivities (mA/cm)

BB. 30	0.0008
BB. 130A	0.0026
BB. 160A	0.0045
BB. 250A	0.0085
BB. 500A	0.04
BB. 3000A	4.0
BB. 5000A	10.0

NEP

New Electronic Products Ltd

MAKERS OF SCIENTIFIC MEDICAL AND INDUSTRIAL INSTRUMENTS

Suppliers of recording instruments and systems to the aircraft and G.W. industries, Government establishments, Admiralty, etc., A.I.D. approved

Head office and works: 360 Kennington Rd London SE11 RELiance 5161

the Atom

AT HOME AND ABROAD—ON LAND AND SEA

Simon-Carves, in association with The General Electric Company of England,
are building the first commercial nuclear power station in Scotland and the first in Japan
—the latter the first in the world to be designed to withstand earthquakes.
They are also developing nuclear power plant for marine propulsion.
The combined experience and resources of these two great companies
in research, construction and contracting are playing a leading part in keeping
British nuclear engineering in the forefront of the world.

Simon-Carves Ltd

SIMON ENGINEERING GROUP

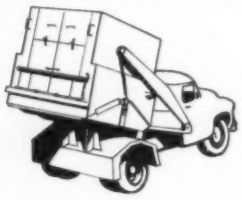
NUCLEAR POWER DIVISION / Cheadle Heath Stockport

IN ASSOCIATION WITH THE GENERAL ELECTRIC CO LTD OF ENGLAND

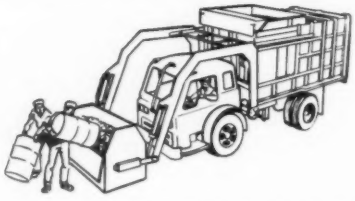
Tick **No 31** on reply card for further details

THE
DEMPSTER DUMPSTER
SYSTEMS

the *NEW SYSTEM* of waste disposal

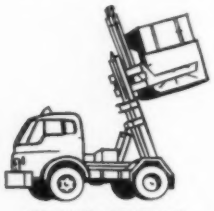


LFW TYPE WITH CONTAINERS IN CARRYING POSITION.

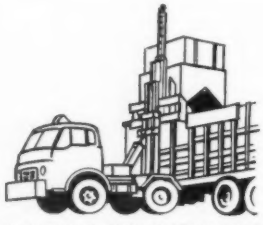


DUMPMASTER CONTAINERS LOADED AT GROUND LEVEL

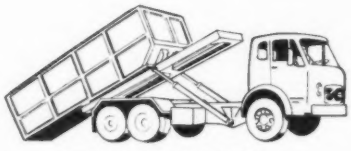
DUMPMASTER CONTENTS EMPTIED INTO COMPACTION BODY



GRD RAISES CONTAINER READY FOR DUMPING



DUMPING FROM A 'DROP BOTTOM' CONTAINER



DINOSAUR FOR BULK DISPOSAL.

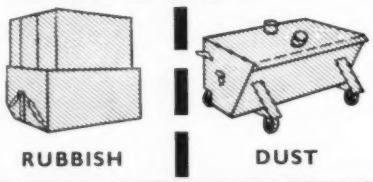
The entire waste and by-products of a major industrial plant can be handled by one man—the driver/operator of a Dempster-Dumpster vehicle—and a series of containers strategically located throughout the plant. Unsightly and insanitary rubbish heaps are abolished. Containers are designed to suit every type of application and sizes range up to 15 cu. yards capacity.

When journeys to outside tips are involved, the "Dumpmaster" range of self-loading, compaction bodied vehicles can lift and empty into their own bodies, containers of up to 6 cu. yards capacity and compress the material in a ratio of up to 3 : 1.

For large scale bulk collection and movement, the Dempster "Dinosaur" is capable of picking up or setting down, off-loading onto raised wharf or tipping to empty, bodies of up to 40 cu. yards capacity.

Dempster systems are adaptable to meet every waste disposal problem and are suitable for many process materials handling applications. If you have a waste handling problem or are collecting by conventional methods why not ask for a survey to be made without obligation? Further information on request—films also available by arrangement.

ALL KINDS OF WASTE CAN BE 'CONTAINERISED'



RUBBISH | DUST

SLUDGE | LIQUIDS

THERE IS A SYSTEM IN THE DEMPSTER RANGE TO SUIT EVERY REQUIREMENT

PDE

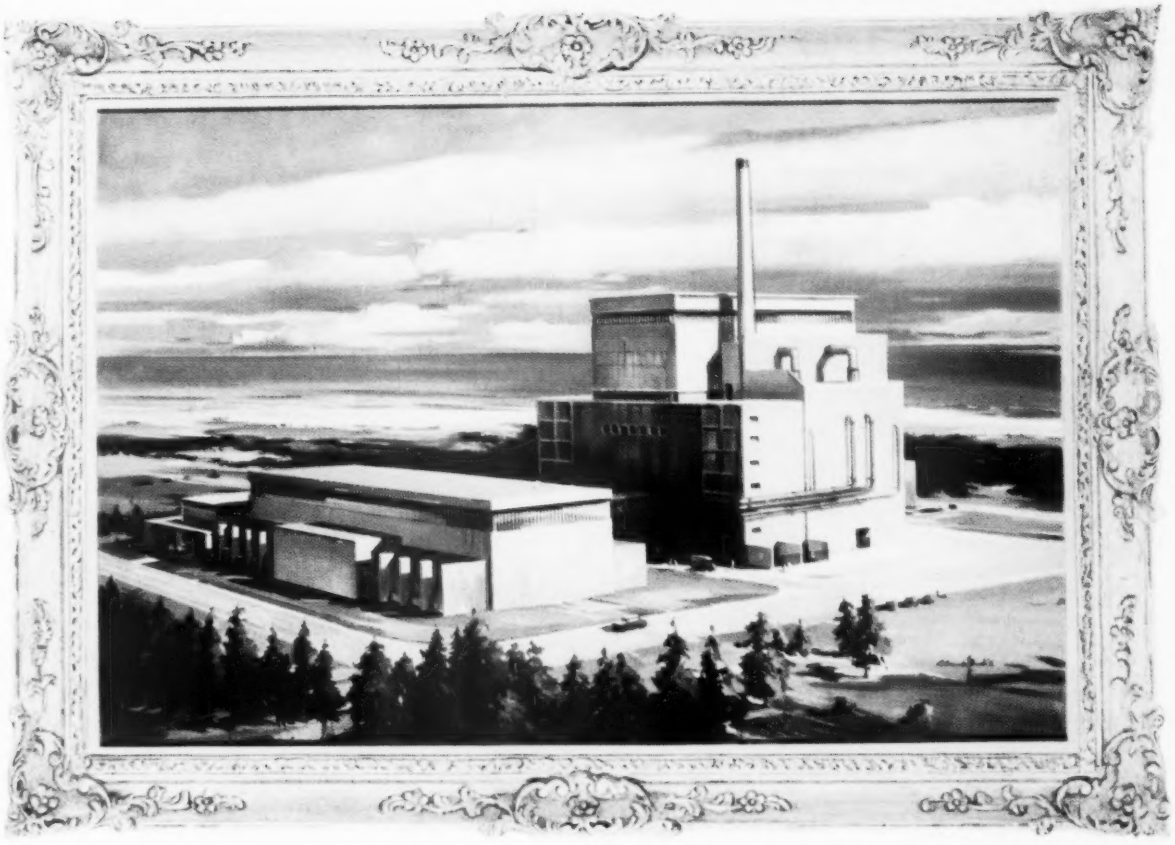
Manufactured under license in U.K. by

Powell Duffryn Engineering Co. Ltd.

(formerly Cambrian Wagon & Engineering Co. Ltd.)

A MEMBER OF THE POWELL DUFFRYN GROUP OF COMPANIES

CAMBRIAN WORKS · MAINDY · CARDIFF · TELEPHONE: CARDIFF 29611 · TELEGRAMS: "PEEDENG" CARDIFF



Claude Buckle's oil painting of the 150 *MW nuclear power station to be built at Tokai-Mura Japan, was presented to the Japan Atomic Power Company on the occasion of the signing of the contract in Tokyo in December* 1959.

G.E.C.

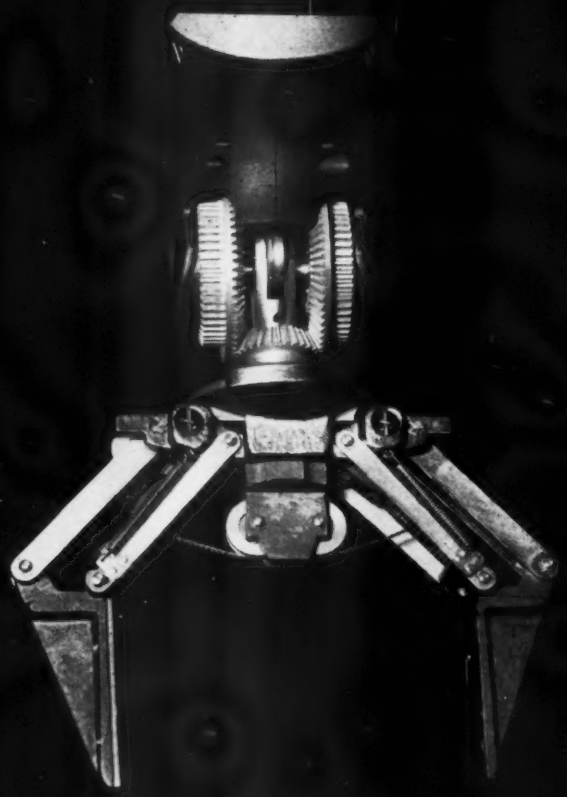
THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND AND SIMON-CARVES LIMITED

Main contractor : The General Electric Co. Ltd. (GEC/Simon-Carves atomic energy group)

The 320 MW Nuclear Generating Station now being constructed at Hunterston for the South of Scotland Electricity Board will employ 64 Hayward Tyler glandless motor pump units for its high and low pressure circulating systems.

HAYWARD TYLER
& CO. LTD., LUTON AND EAST KILBRIDE

LONDON OFFICE: SALISBURY HOUSE, FINSBURY CIRCUS, LONDON, E.C.2. NATional 9306



Manipulators

The manipulators used at atomic establishments have to operate under exacting conditions. They are constructed of stainless steel and Kanigen plated aluminium and the plate serves two functions. It resists corrosion and, because of the smoothness of the finish, it also assists in decontamination of the component parts from radio-active material; and the combination of stainless steel and Kanigen plated aluminium reduces the electro potential difference between the component parts. These manipulators, manufactured by Savage & Parsons Ltd., are supplied to users all over the world. Kanigen is used on the aluminium parts of the Tong End assembly and the Ma ·er Hand assembly.

Kanigen

A HARD & CORROSION RESISTANT PLATE

KANIGEN is a nickel-phosphorus plate deposited by chemical reduction: thickness can be controlled to fine limits and is of complete and uniform coverage.

PROPERTIES:

Composition	92% Nickel 8% Phosphorus
Melting point	890°C.
Electrical resistivity	60 microohm cm.
Hardness	500—1,000 V.P.N. according to heat treatment
Coverage	Extremely uniform

Kanigen can be applied to all ferrous metals, aluminium, copper and brass. The plating plant at Oldbury has now been extended, two extra plating tanks are in operation and enquiries for jobbing plating are welcomed. Full information is available on request.

Albright & Wilson
(MFG) LTD
Kanigen Department
I KNIGHTSBRIDGE GREEN · LONDON SWI

Kanigen is a regd. trademark of Albright & Wilson Ltd

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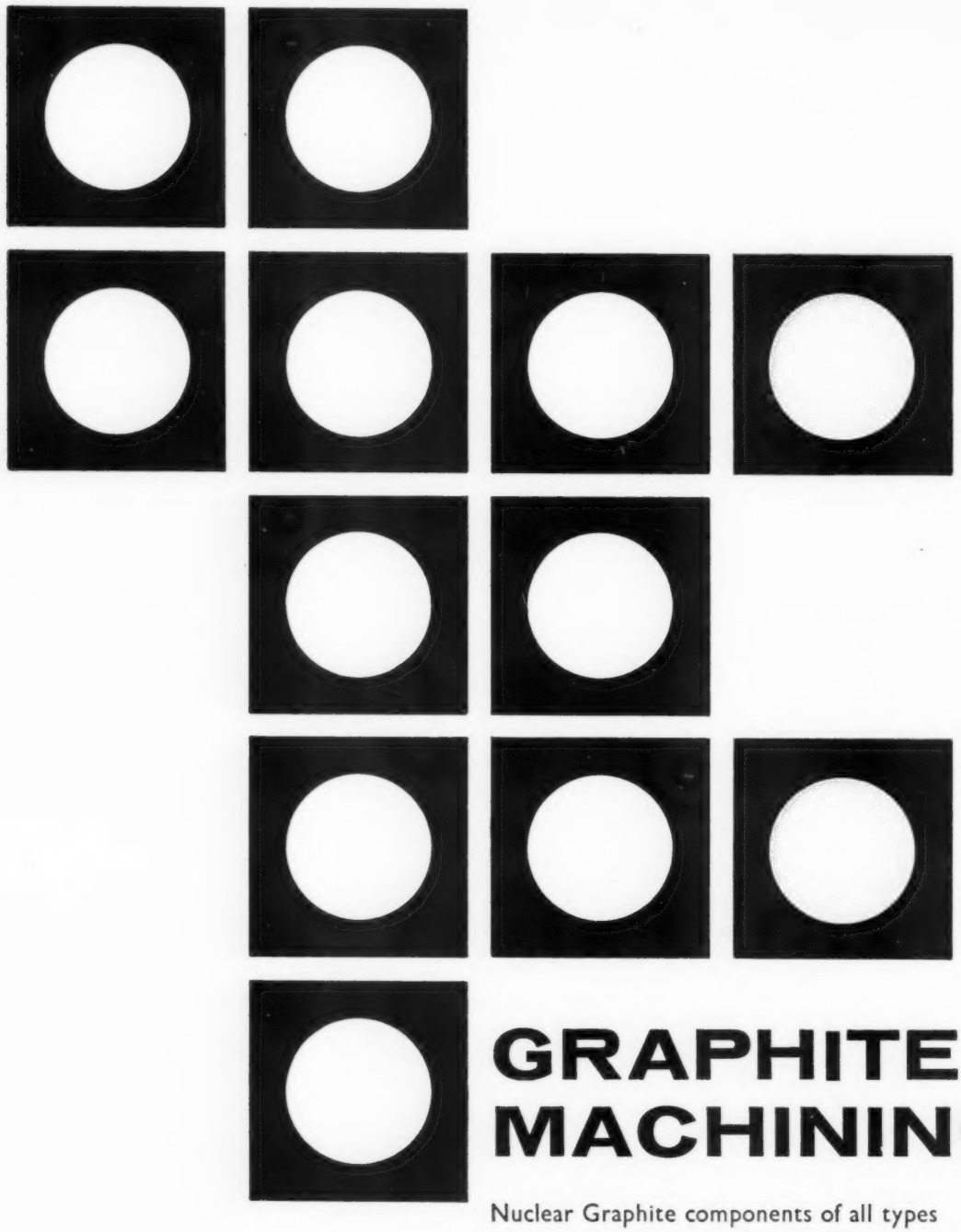
KANIGEN

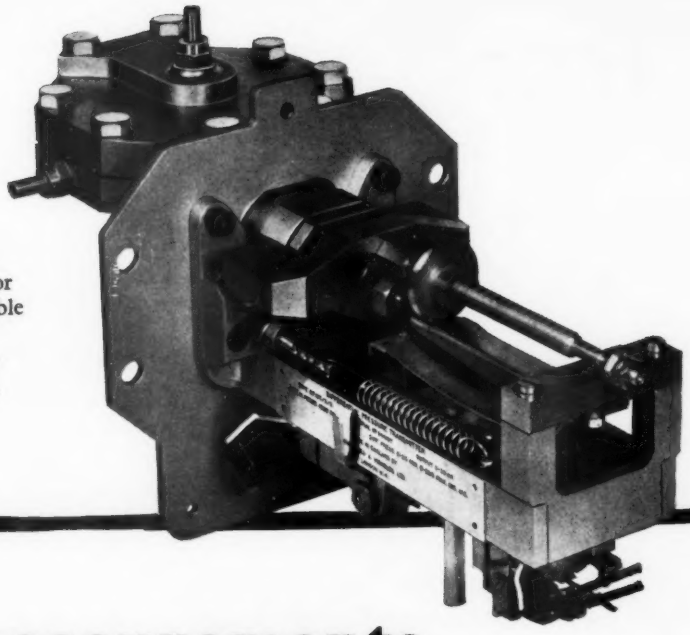


GRAPHITE MACHINING

Nuclear Graphite components of all types for atomic energy purposes machined under clean conditions.
Bulk deliveries now in progress to Hunterston and other Nuclear Power stations.

THE POWELL DUFFRYN GROUP OF COMPANIES

POWELL DUFFRYN CARBON PRODUCTS LTD.,
NUCLEAR GRAPHITE DIVISION
Springfield Road, Hayes, Middlesex. Telephone Hayes 3994



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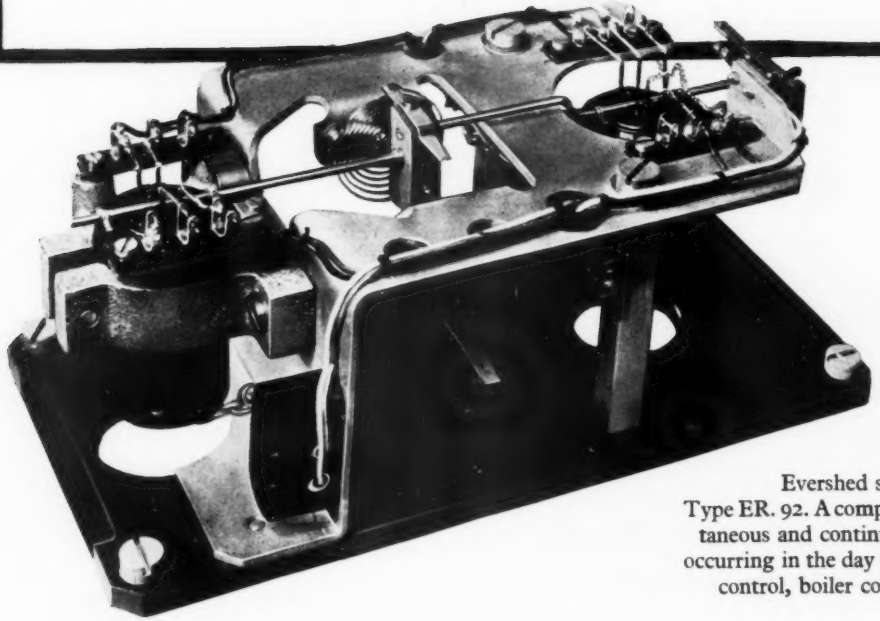

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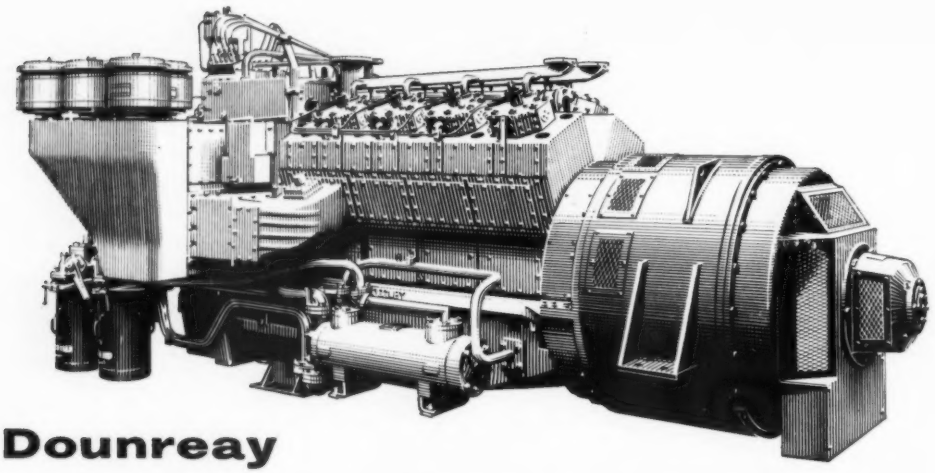

At Dounreay

Crossley Diesels drive these

Versatility and reliability, these are the qualities demanded of the diesel plant and at the United Kingdom Atomic Energy Authority's nuclear power station at Dounreay for the widely differing duties carried out by the 34 Crossley Scavenge Pump two-cycle diesel engines.

MAIN GENERATOR HOUSE—FAST REACTOR

Twenty "ESL" five cylinder engines, rated at 200 b.h.p. at 600 r.p.m., driving 120 kW Bruce Peebles alternators and six "ES Vee" eight cylinder engines, rated at 360 b.h.p. each at 600 r.p.m. driving 220 kW Bruce Peebles alternators.

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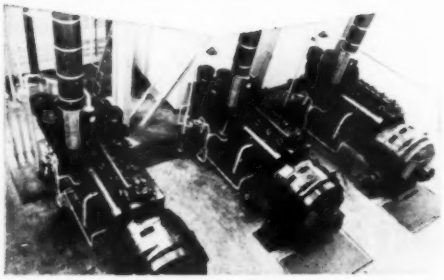

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CROSSLEY DIESEL ENGINES

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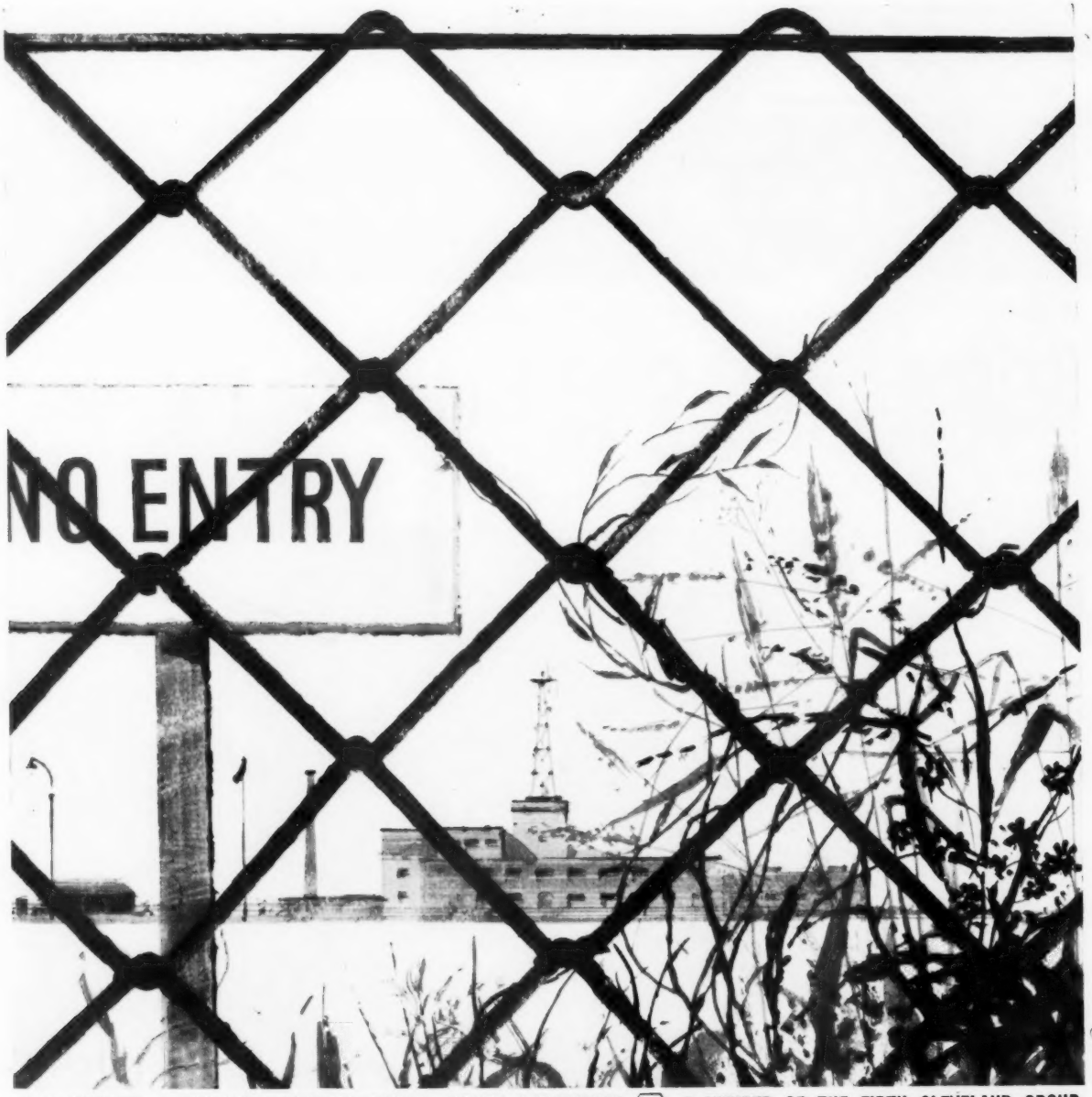

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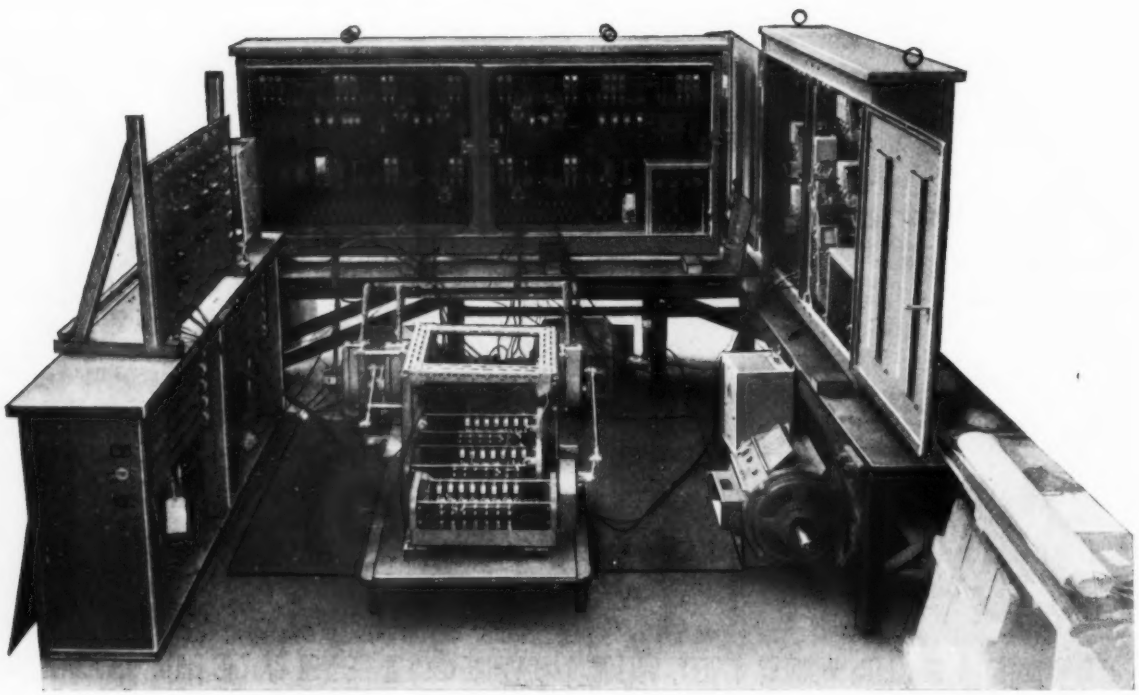

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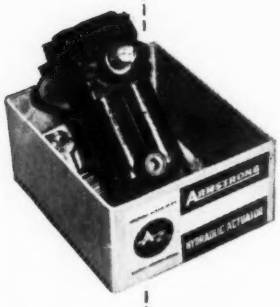

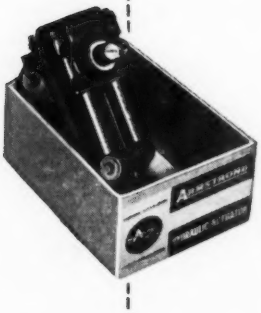

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You can select a combination of the various types of Armstrong Actuator units to suit your individual requirements. Accurate assembly requires only elementary engineering knowledge; simple instructions are provided and stock embodiment items supplied.

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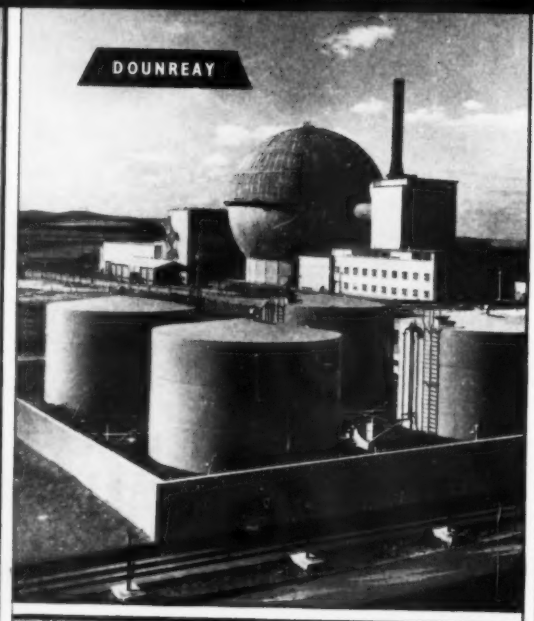
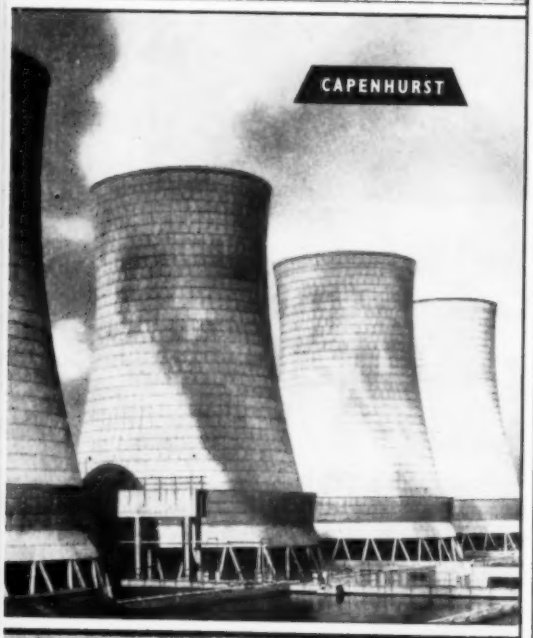
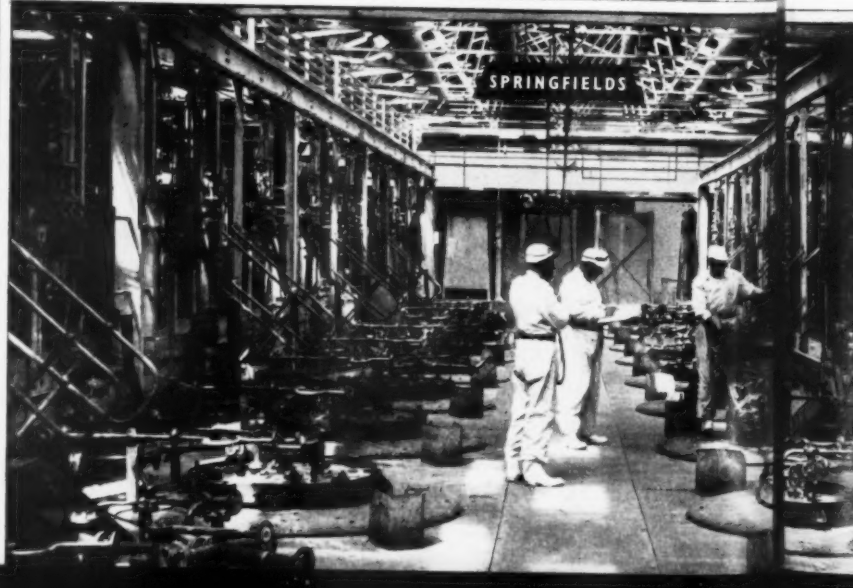
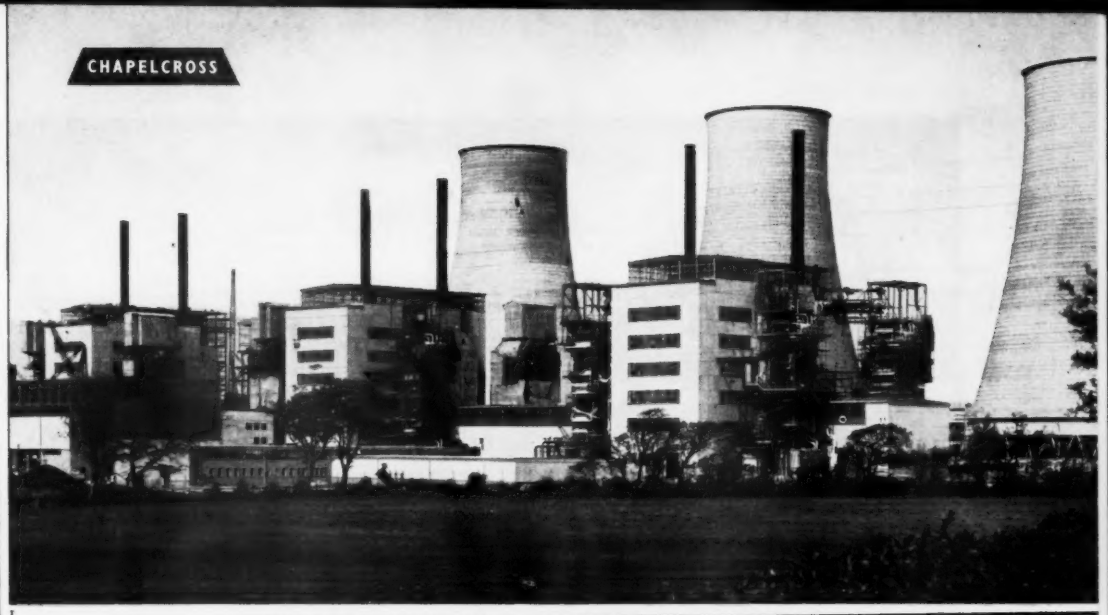

DOUNREAY


CAPENHURST


SPRINGFIELDS



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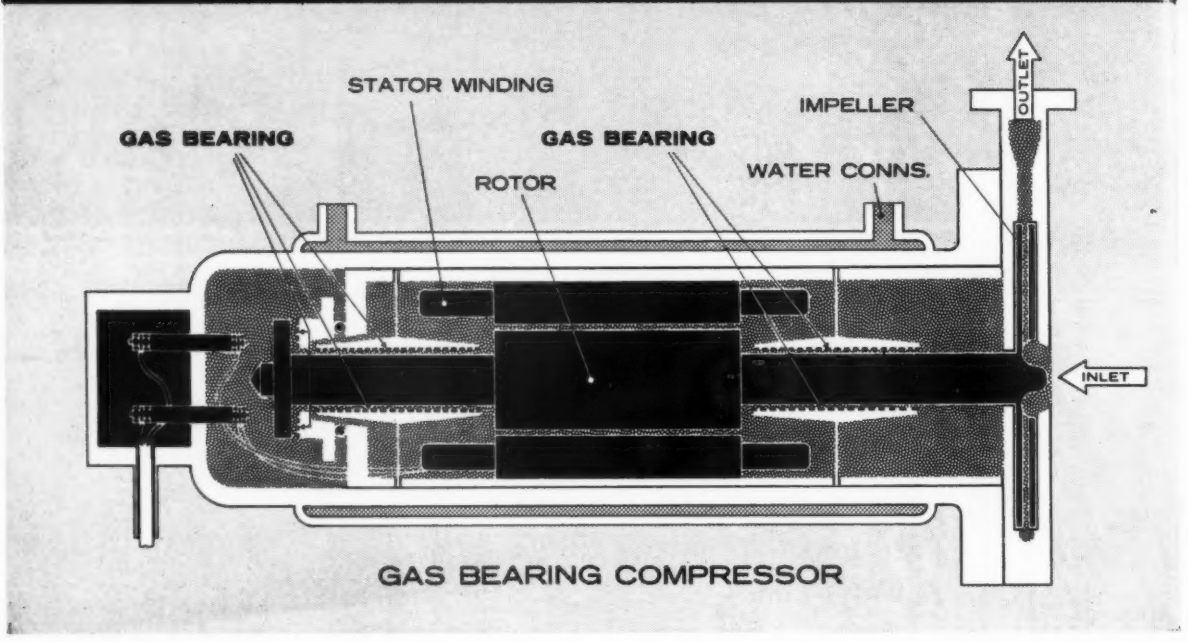
Gas bearing compressors– totally enclosed, lubricant free – circulate gases up to 700°C, 2,000 psi, without contamination . . .



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One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce gas bearing compressors. The range covers a very wide performance capacity, from 0°—700°C gas operating temperature, 15—2,000 psi and 0.5—2,000 hp power input.

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Gas bearings have several great advantages over oil lubricated bearings: the load-carrying capacity increases with speed, temperature and pressure; the bearings are supported on a film of the gas which is being circulated in the system, so there is no metal-to-metal contact under operating conditions and wear and maintenance are reduced to an absolute minimum; perfect cleanliness is preserved at all times.

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Bristol Siddeley gas bearings were developed originally to meet the extremely fine limits of operating purity and precision of manufacture demanded by the advent of nuclear engineering. But gas bearings have many other applications where a rotating shaft must be supported in such a way that no contamination and leakage can be allowed and where the supply of chemically pure fluids or gases is essential: in the textile, chemical engineering, pharmaceutical, food storage and processing industries, to name but a few.

For further information about Bristol Siddeley gas bearing compressors and gas bearings, please write to H. J. Prince, Sales Manager, Reactor Components Division, Bristol Siddeley Engines Limited, P.O. Box 17, Coventry, England.

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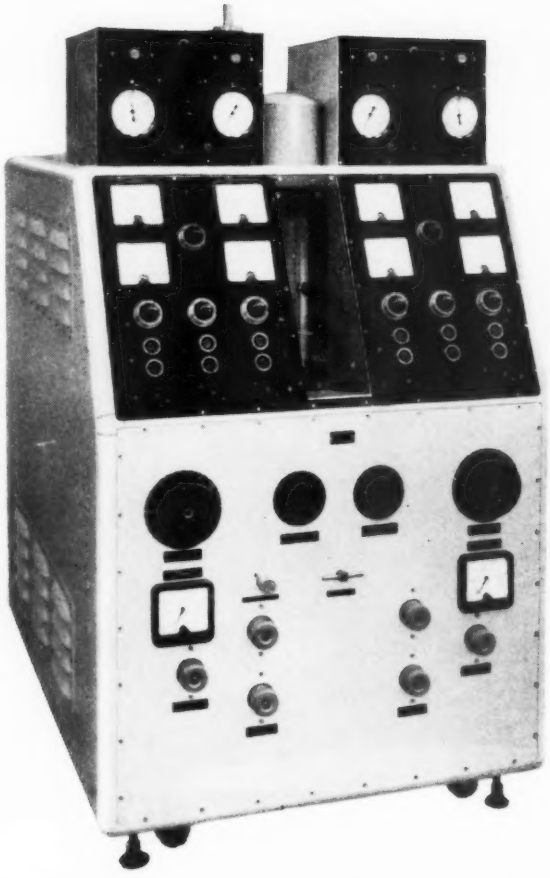

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THE MARK IV SELF-CIRCULATING GAS PURIFIER

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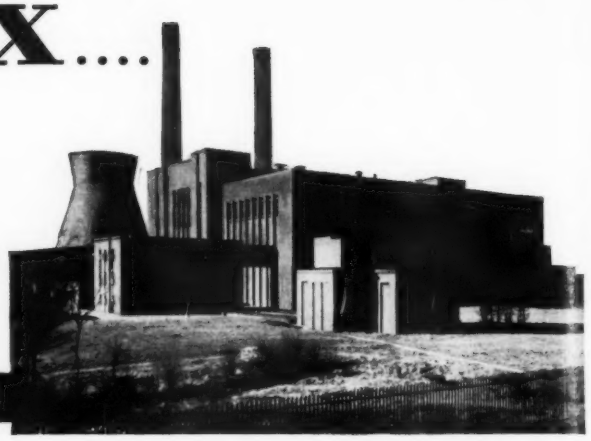
Then . . .

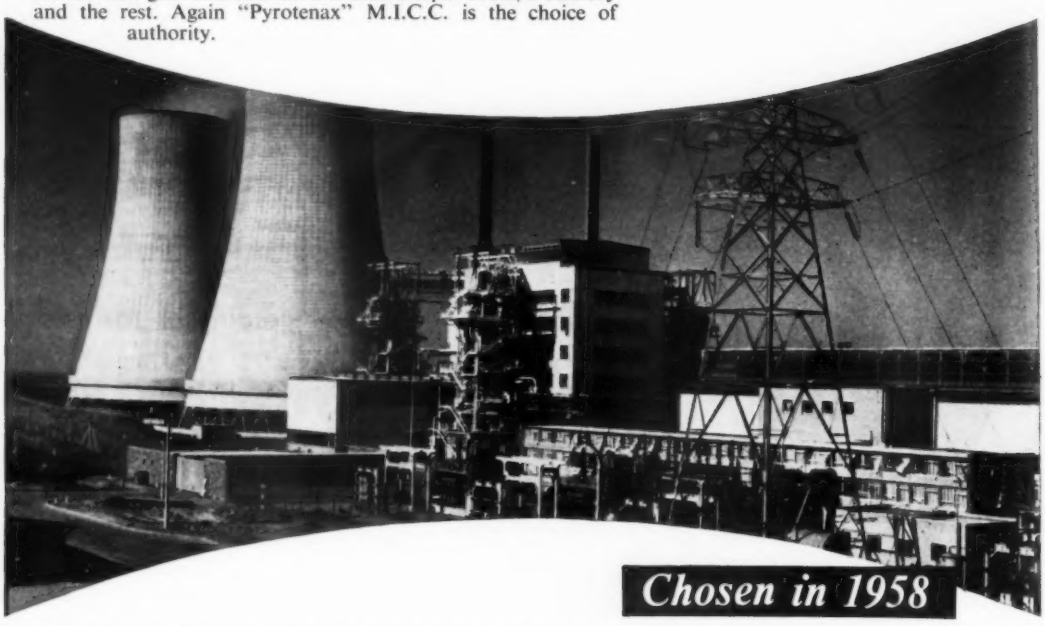
Little Barfield—the most modern power station of its day, with equipment, instruments and cabling the best available. The cabling? "Pyrotenax" M.I.C.C. to be sure. And it is still giving yeoman service today!



Chosen in 1938

Now . . .

The pattern changes, bringing new techniques and new structures. Calder Hall goes into action. And then Chapel Cross, Dounreay and the rest. Again "Pyrotenax" M.I.C.C. is the choice of authority.



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Whatever the shape of things to come, so long as current has to be carried, "Pyrotenax" will play its vital part . . . a confident prediction based on experience of the past. Current carrying is always best left to "Pyrotenax"!

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GD123

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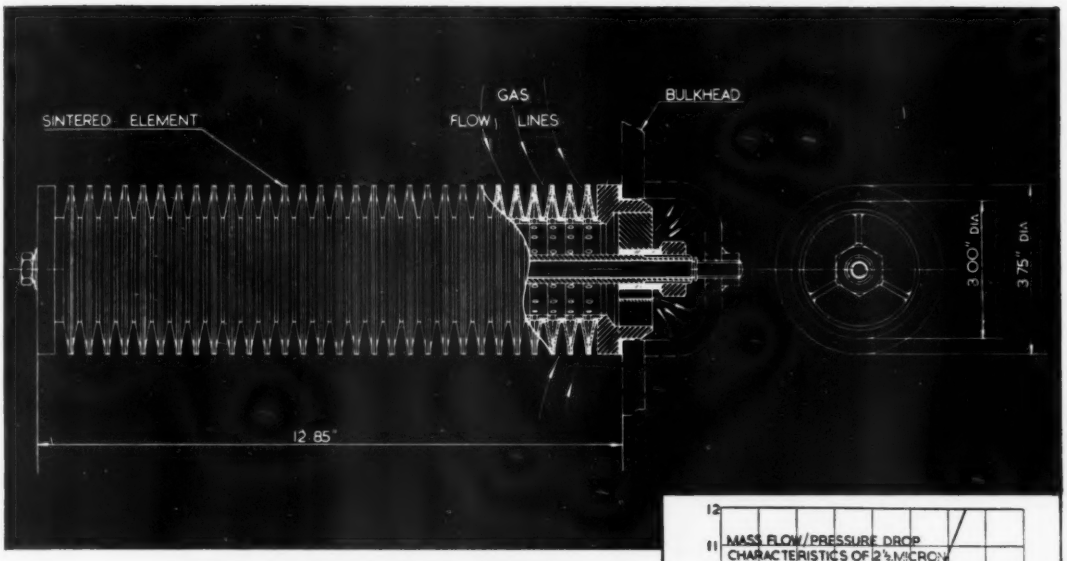
GAS FILTRATION



BY FAIREY

GUARANTEED POSITIVE FILTRATION
TO 5 OR 2½ MICRONS

MAXIMUM FLOW AREA FOR MINIMUM OVERALL BULK
(375 sq. ins. for the filter shown)

LOW INSTALLATION COSTS

EASILY CLEANED

ROBUST CONSTRUCTION

FREEDOM FROM THERMAL SHOCK PROBLEMS

Fairey gas filtration will be used in the new nuclear power station at Trawsfynydd, North Wales.

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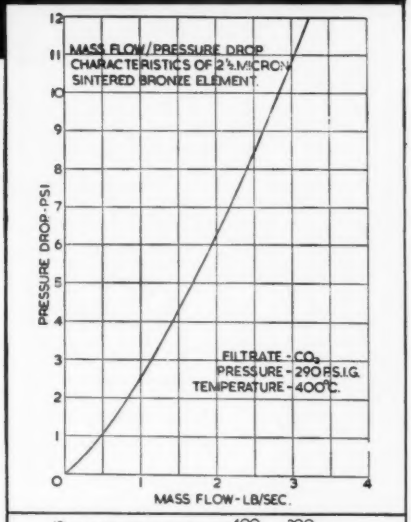
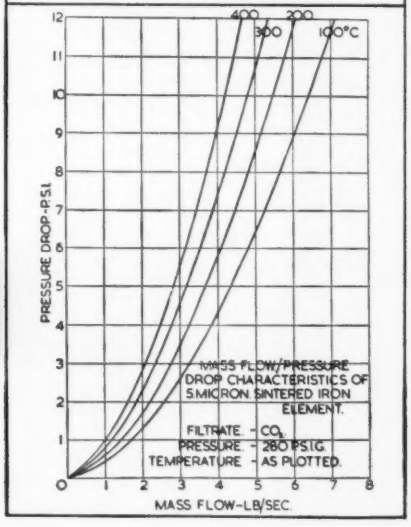

MASS FLOW/PRESSURE DROP CHARACTERISTICS OF 2½ MICRON SINTERED BRONZE ELEMENT.
FILTRATE - CO_2
PRESSURE - 290 P.S.I.G.
TEMPERATURE - 400°C.
PRESSURE DROP - P.S.I.
MASS FLOW - LB/SEC.



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PLANNAIR GAS CIRCULATION BLOWERS FOR NUCLEAR PROJECTS

Re-affirming their leadership in matters of forced fluid flow temperature control, Plannair are now engaged upon intensive design and development of gas circulating blowers for various nuclear projects.

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Reliable Honeywell instruments stand guard against waste and danger . . . in the central control room at Dounreay and in the containment sphere where the reactor itself is housed.

£20,000,000 protected at Dounreay . . .

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Specification Sheet 164 (Strip Chart Recorders)	☐
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A massive investment of supreme national importance, the reactor station at Dounreay is monitored by Honeywell instruments in three vital ways:

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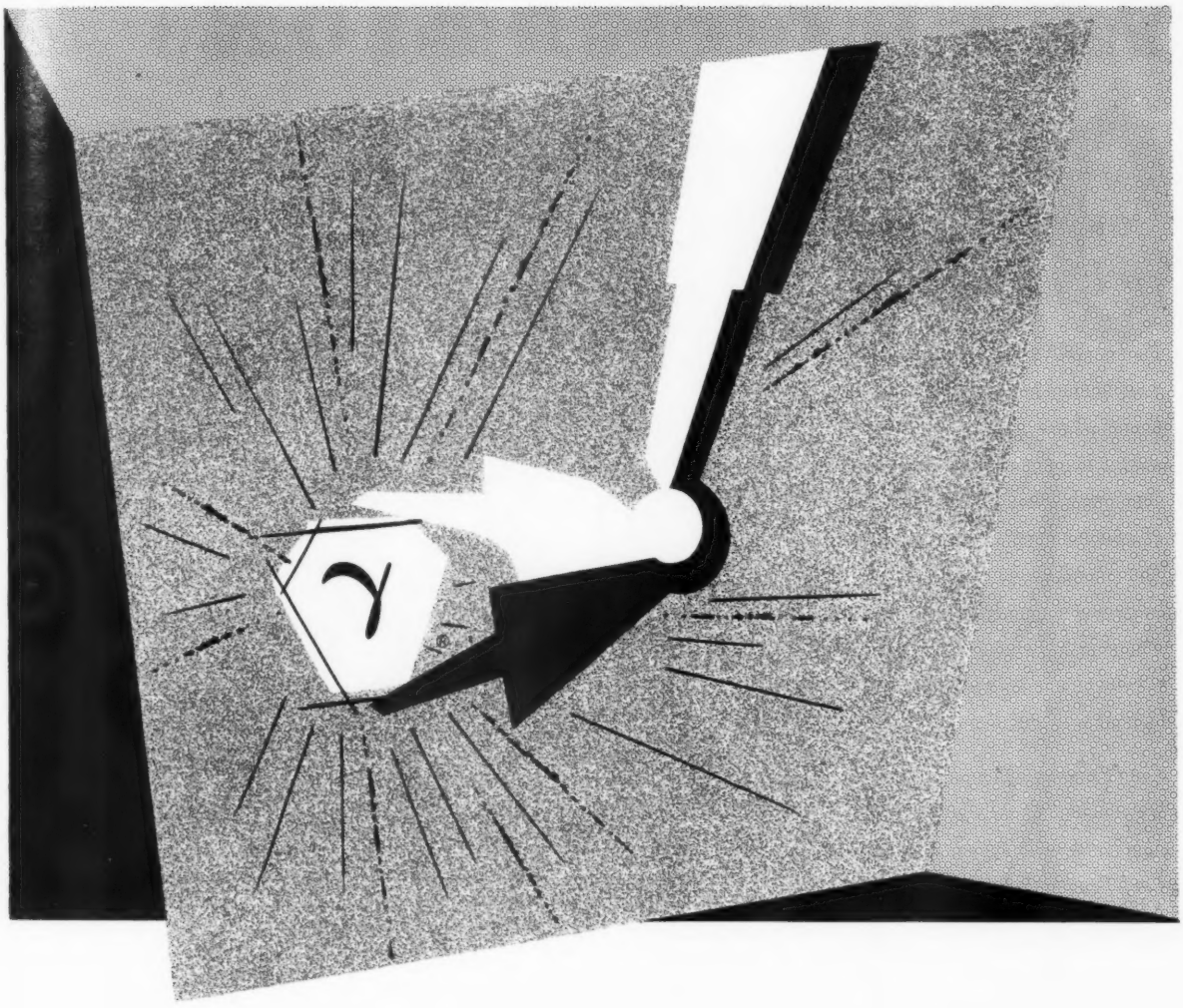

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The use of isotopes in industrial radiography has been expanding rapidly in recent years. The sudden growth stems from the need for non-destructive inspection equipment, mobile and independent of power requirements.

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Radioactive sources in stainless steel capsules are available from one curie to the kilocurie range. For more information, write for our Gamma Radiography brochure—The Budd Company, International Division, Philadelphia 32, Pa. U.S.A.

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power in its place

Power delivered economically and accurately to the place where you need it — that is the function of Lang Pneumatic Control equipment. It can be used to control any processes or sequence of processes; with Lang Pneutomation in charge, production rises and quality of output is maintained.

Lang Pneumatic Control equipment is available "off the shelf" for inexpensive installation. Plan with Lang Pneumatic for efficient production.

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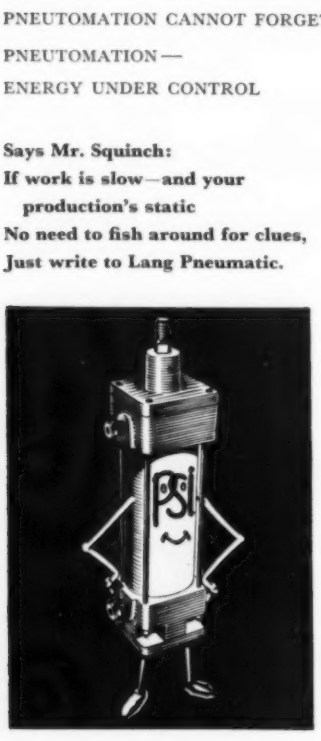
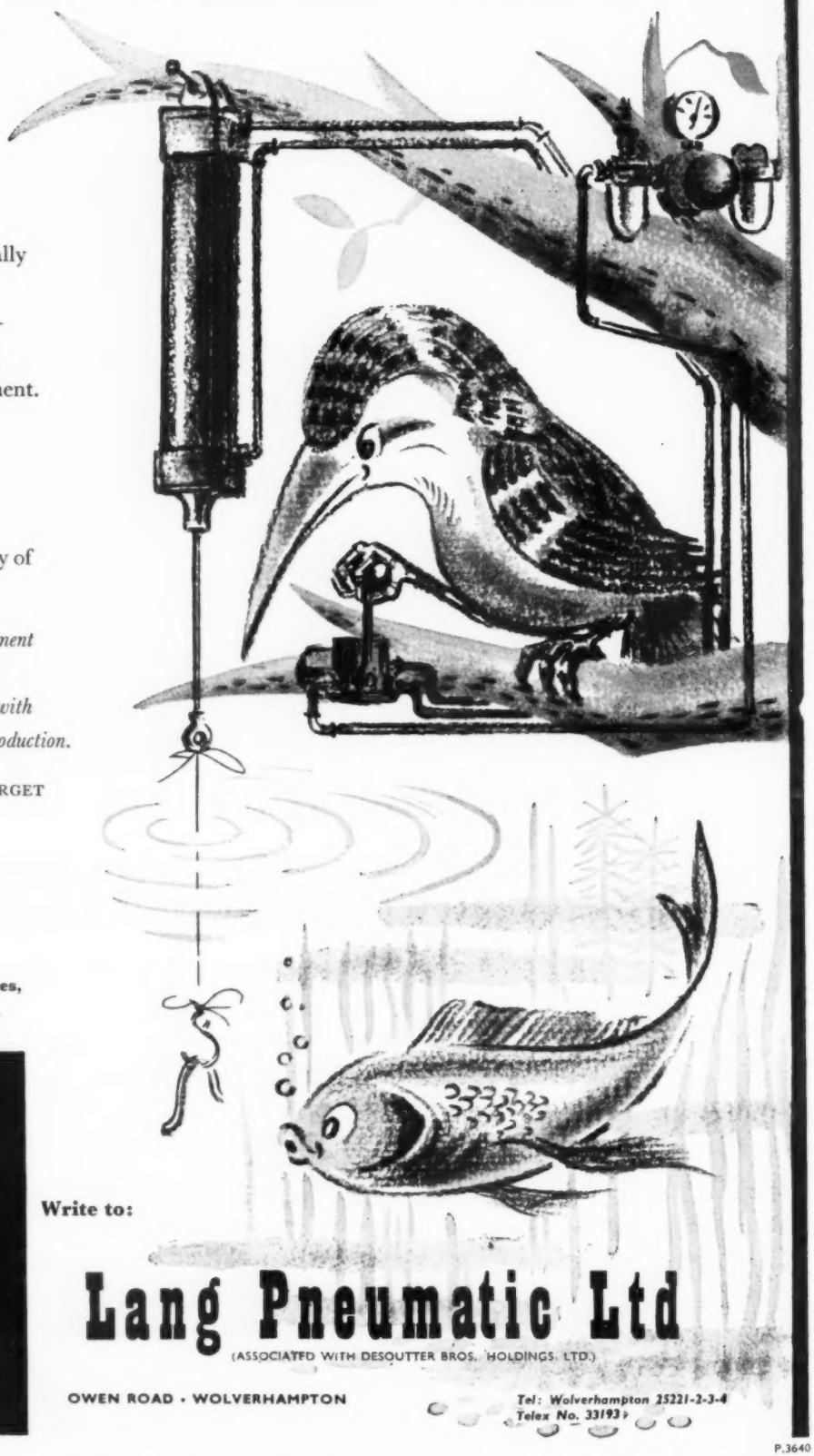
PNEUTOMATION —
ENERGY UNDER CONTROL

Says Mr. Squinch:
If work is slow—and your production's static
No need to fish around for clues,
Just write to Lang Pneumatic.





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"SWIRLYFLO" TUBING, designed and developed for use in our boilers and heaters, has proved to have greater efficiency, in transferring heat over any given length, than any other tube.

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Increased efficiency is obtained through the specially designed spiral twist in the tube, the hot gases passing through them are jostled and bounced against the walls, extracting the maximum amount of heat to be used as well as spent energy. For given results less tube length is required, as a six foot length of Swirlyflo tube does the work of a ten foot length of plain tube. All round advantages are obtained—thicker tube walls giving a 20% longer tube life—shorter tubes mean smaller boilers and saving in floor space.

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The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W.1031.

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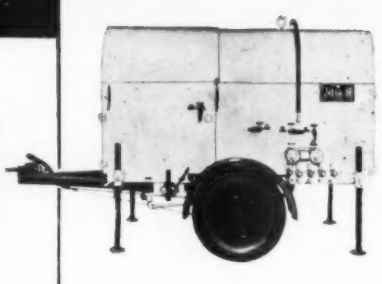

A fully mobile Stream-Line filter.

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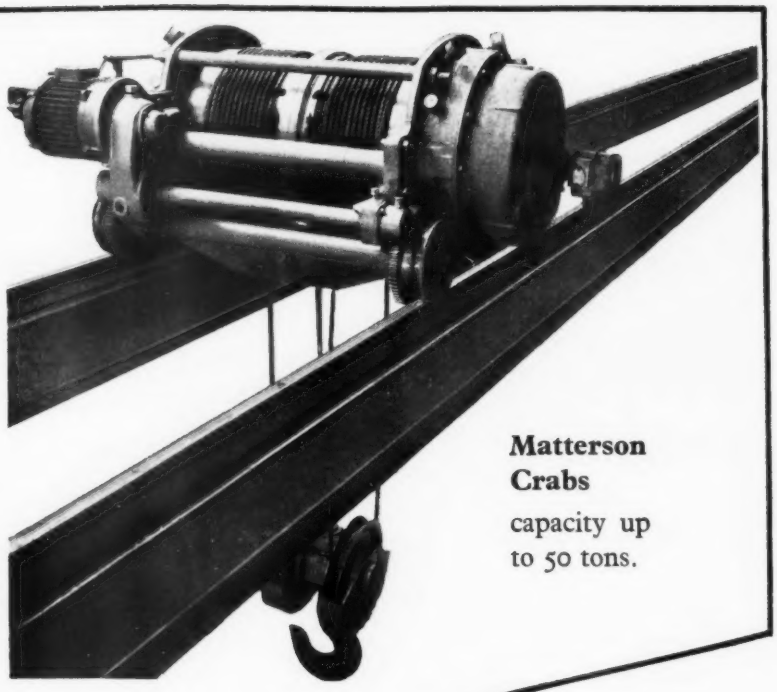

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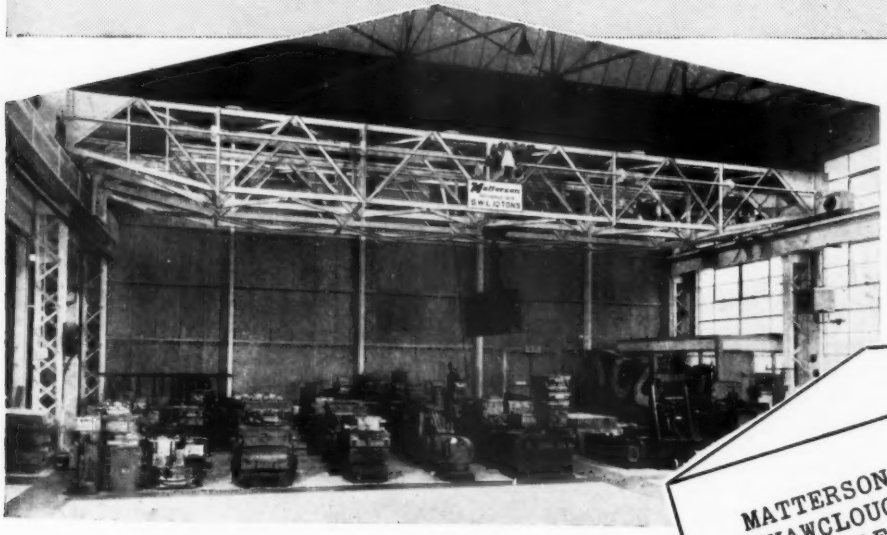

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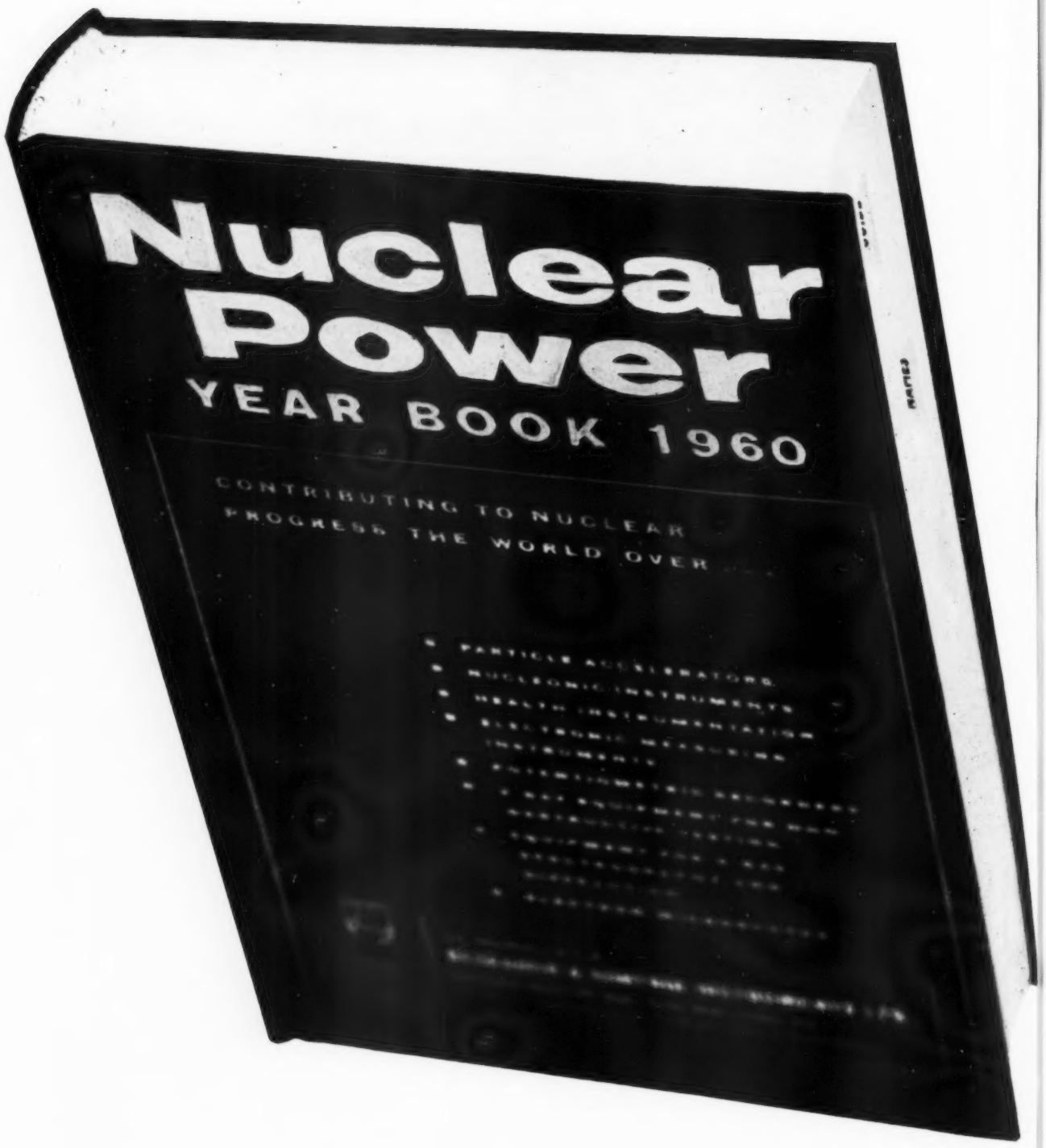
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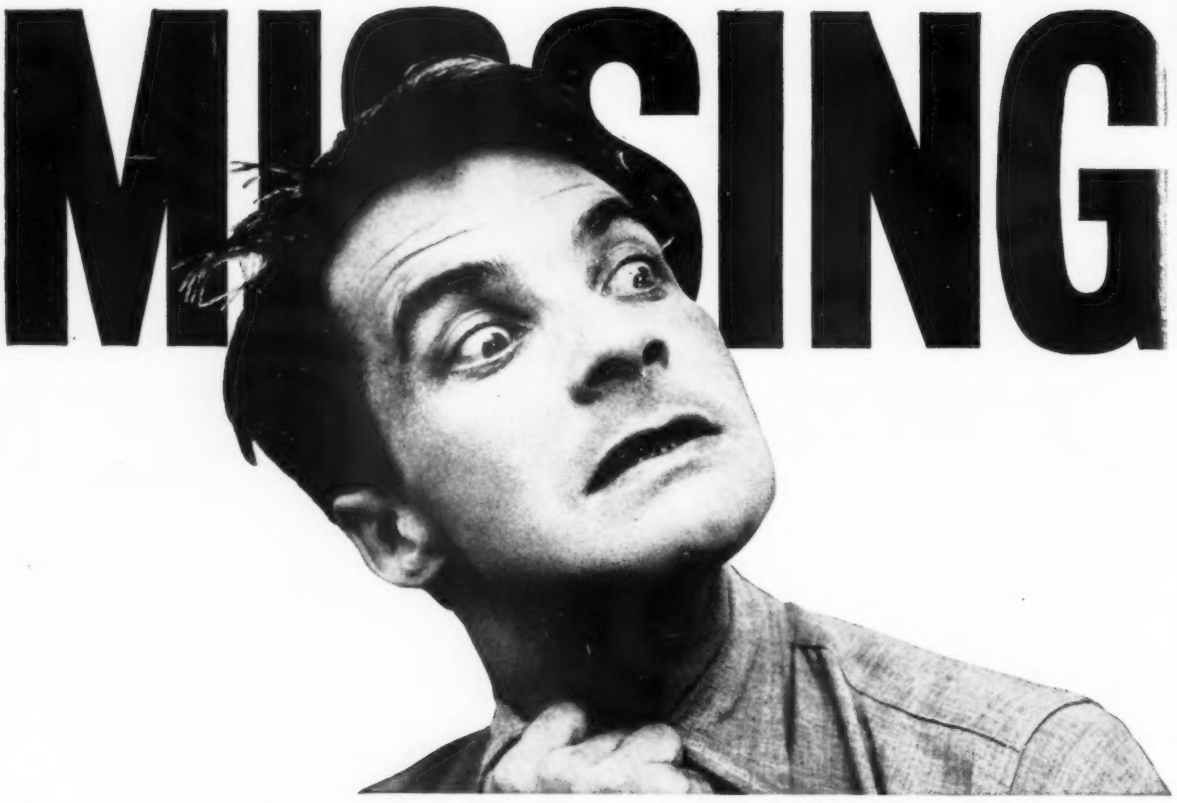

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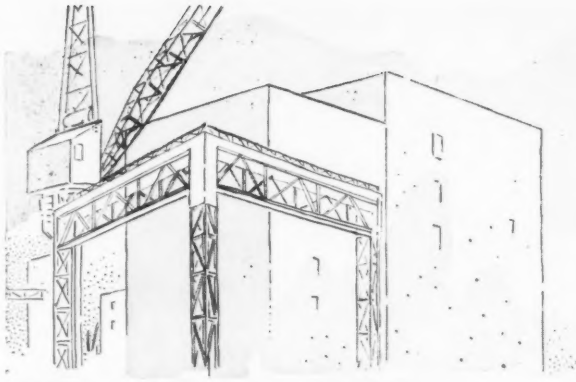

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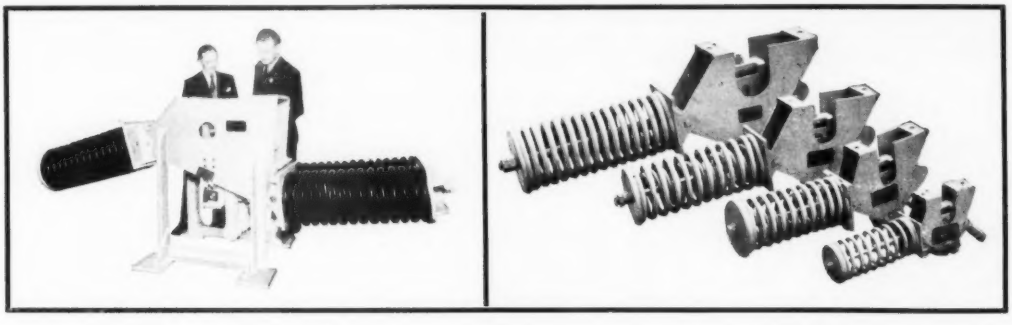
Please write for catalogue covering the 'M' range Constant Support Hangers. Load and travel characteristics are tabulated in this booklet together with much additional information including a section on determining hanger loads.

Catalogues are also available detailing Genspring Variable Support Hangers for applications less critical than those requiring Constant Supports, and Genspring Sway Braces for eliminating shock and vibration.

Below left is the latest addition to the range — Type M7 for loads of 97,800 lb. max.

Below right are the M1 to M4 Constant Supports covering loads from 315 lb. to 22,500 lb. and travels from 1.5″ to 12″.



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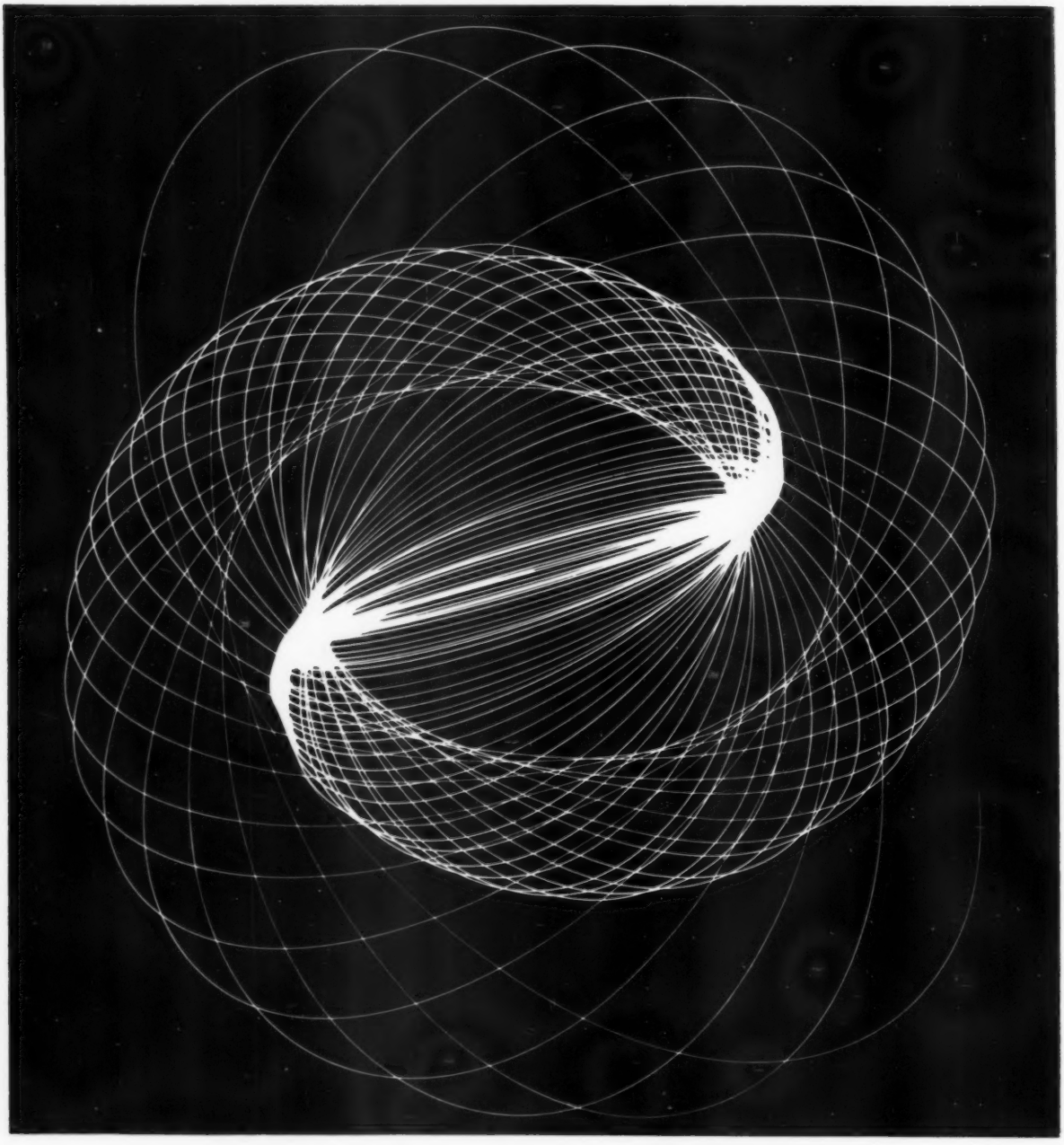

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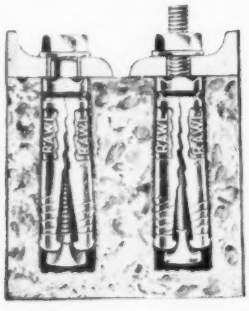

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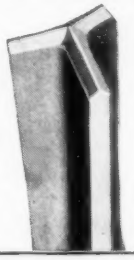

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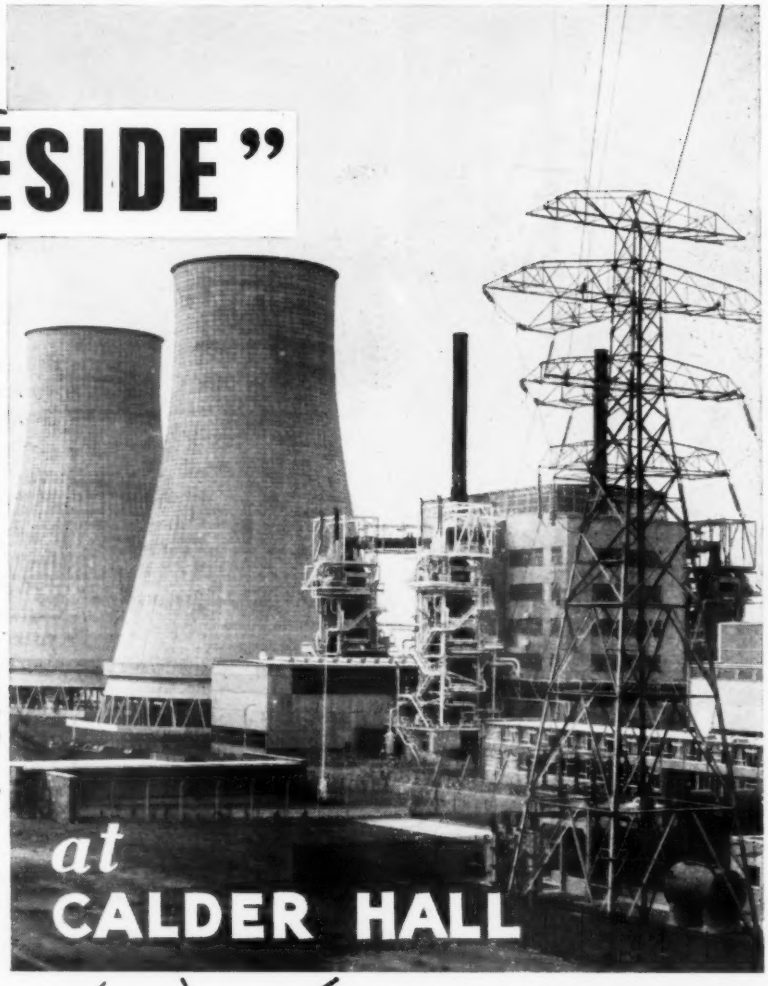

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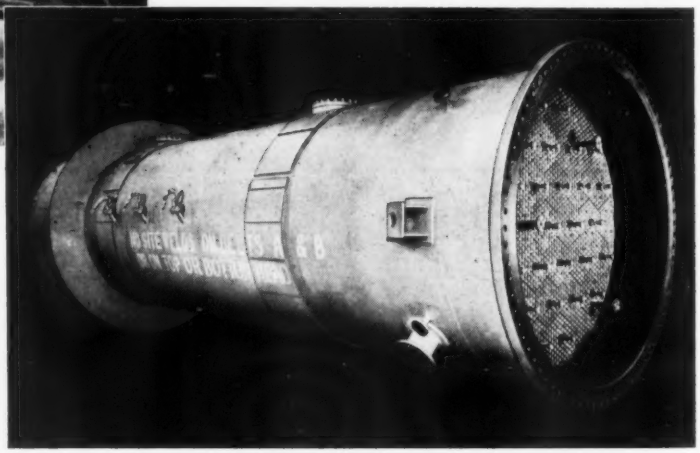
Left: A mild steel jacketed Autoclave to Class 1 construction with electrically driven stirring gear.

Below: This Ethylene Oxide Reactor weighs 135 tons, is 9 ft. 6 ins. in diameter and contains over 15 miles of 1¾ in. dia. catalyst tube.



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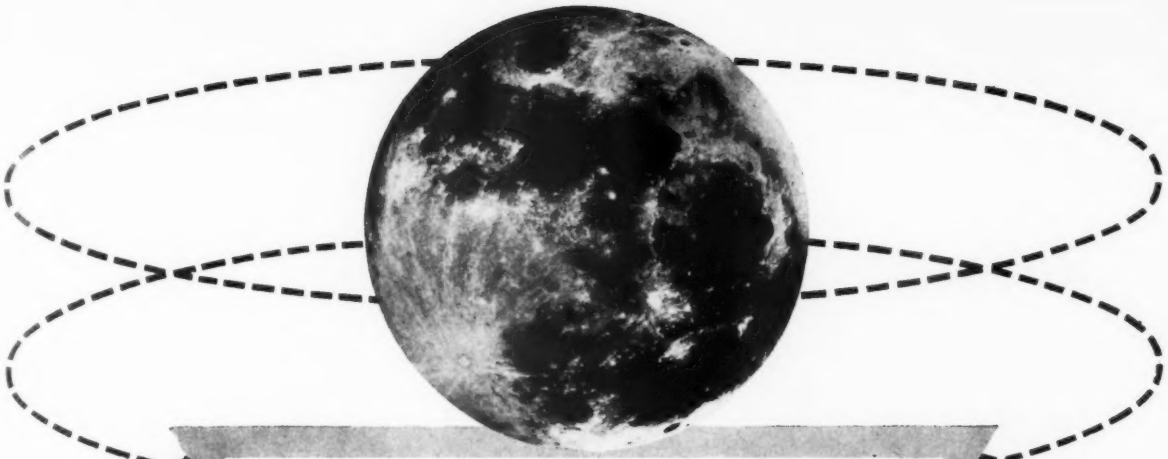

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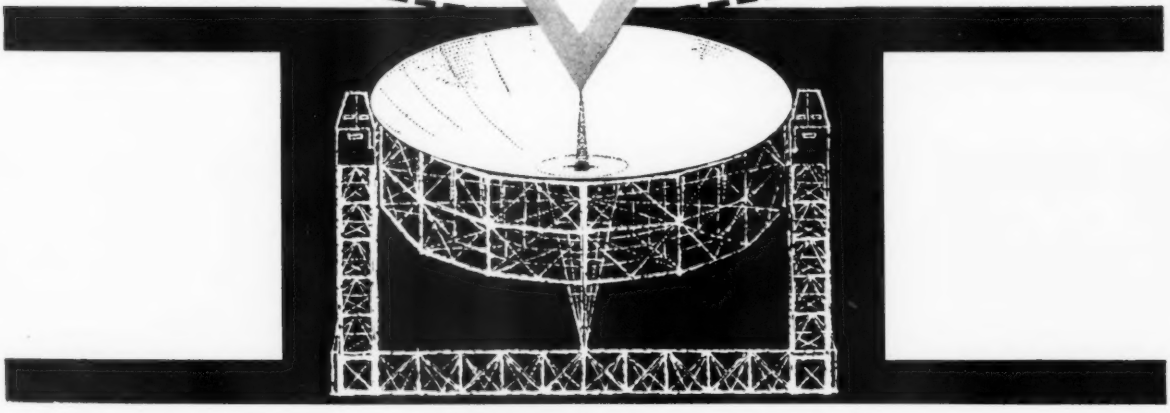

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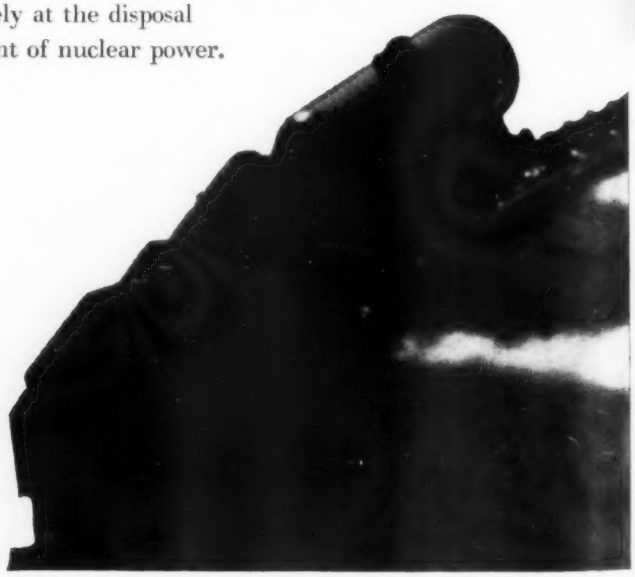

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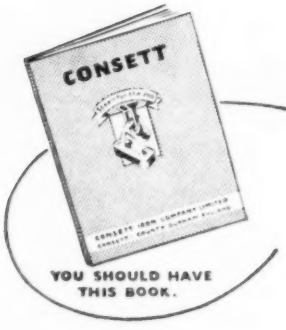

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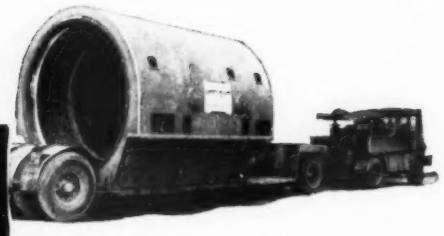

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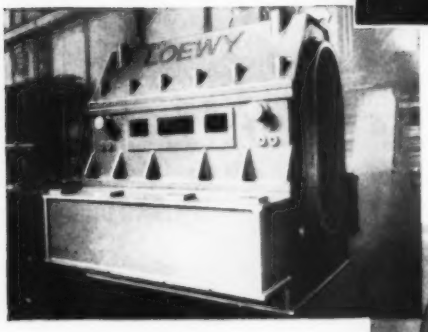

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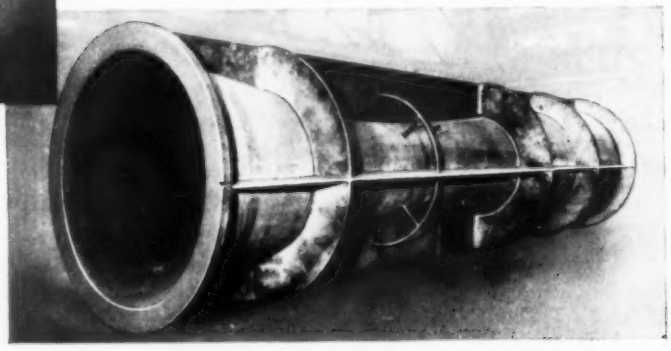

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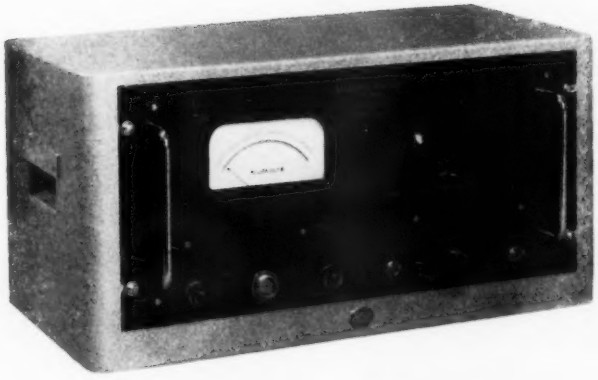

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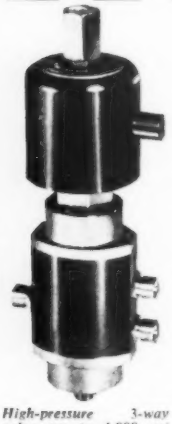
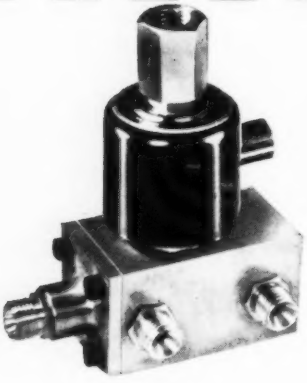
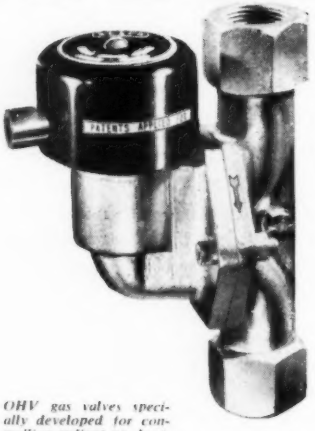


High-pressure 3-way valve up to 4,000 psi for missile and machine tool applications. (TW/VHP.)



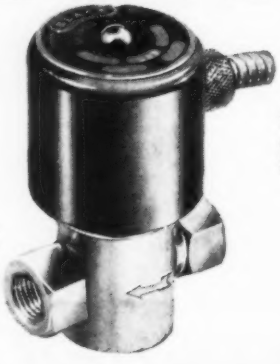
Miniature 4-way air valve for double acting power cylinders. (FW2.)



OHV gas valves specially developed for controlling radiant gas heaters (in co-operation with Horstman Gear Co. Ltd.).

Miniature gas pilot valve. (LGM.)

¼"–1" light duty gas, Oil and air valves. (LG series.)



Solenoid-operated lever valve with reversible cage giving direct or reverse action at will. For high viscosity oils. (HDOL.)

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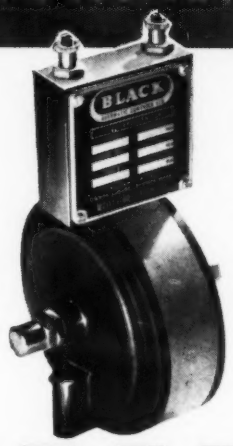
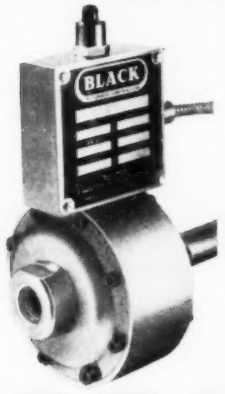


Differential pressure switch incorporating two diaphragms giving operation at very small differentials and very high pressures—fully adjustable. (DPS Mk 11.)

CHARACTERISED by small but robust switch action rated up to 5 amps, the Black range caters for pressure signalling and control functions for all kinds of industrial applications including missile and nuclear energy requirements.



Flow switch in stainless steel. (FSW.)

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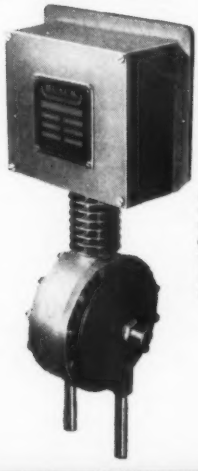
High pressure switch for the range 200-10,000 psi, fully adjustable. (VHPS.)

Miniature pressure switch for sequence operation, can be provided with up to six switches to operate at different pressures. (VPS/MU.)

Barometrically compensated pressure switch. (HPS/V/BC.)



Differential Pressure switch developed for use on CO^2 at pressures up to 250 psig and temperatures up to 350°C. (DPS Mk 11/s.)

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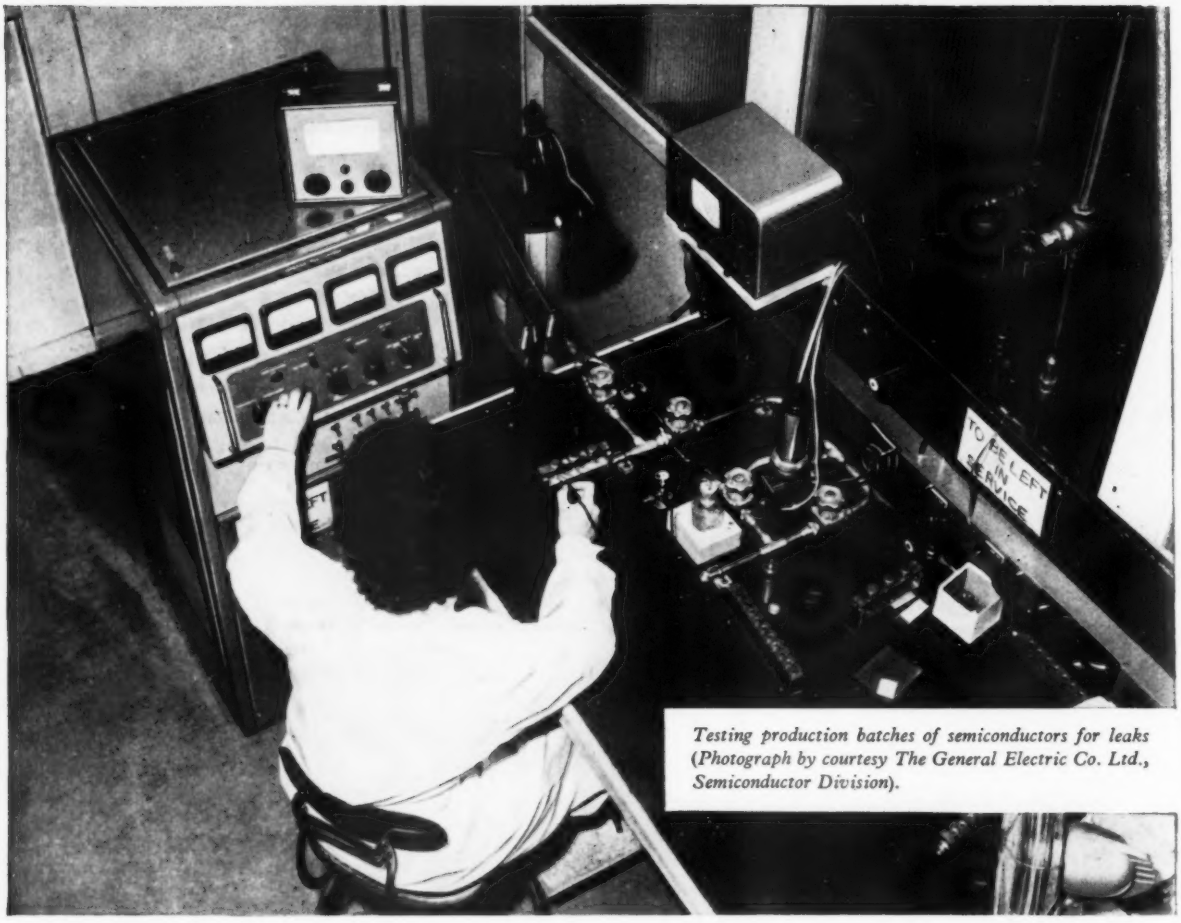

Testing production batches of semiconductors for leaks (Photograph by courtesy The General Electric Co. Ltd., Semiconductor Division).

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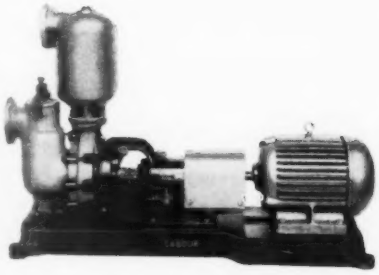
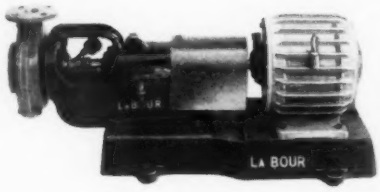
INSTRUMENTATION DIVISION-Scientific Apparatus & X-Ray Department
Trafford Park, Manchester, 17



Type UPL for self priming duties.



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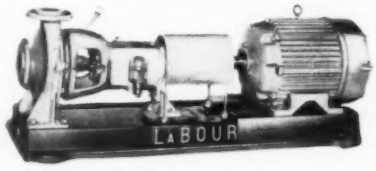

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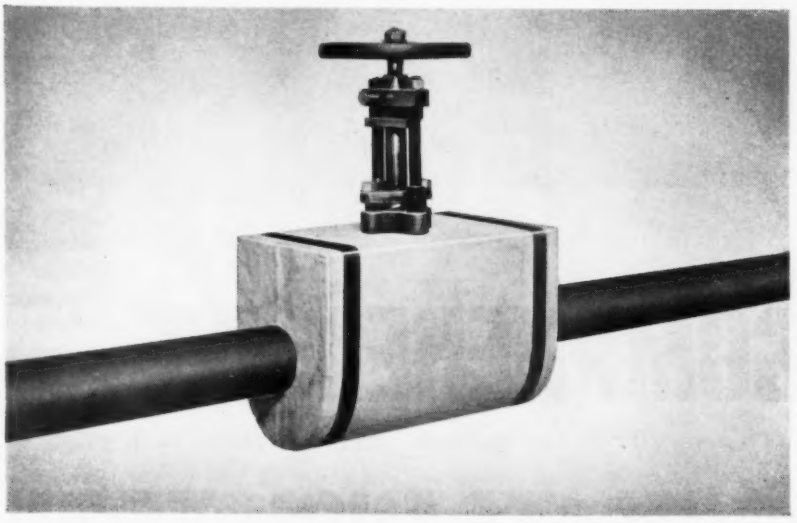

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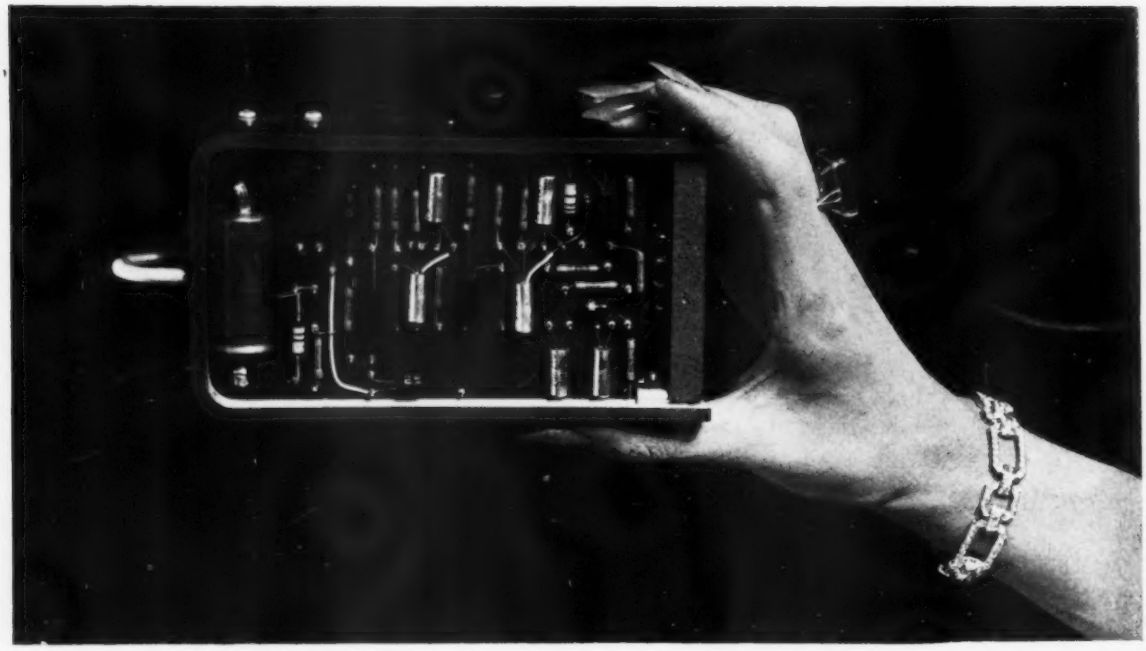

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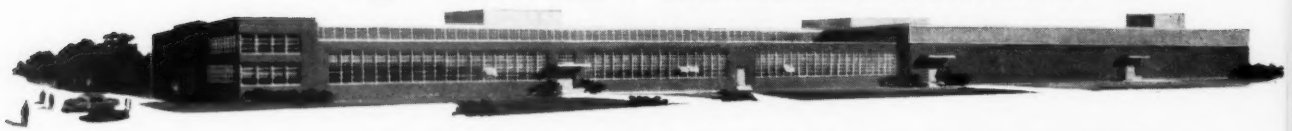

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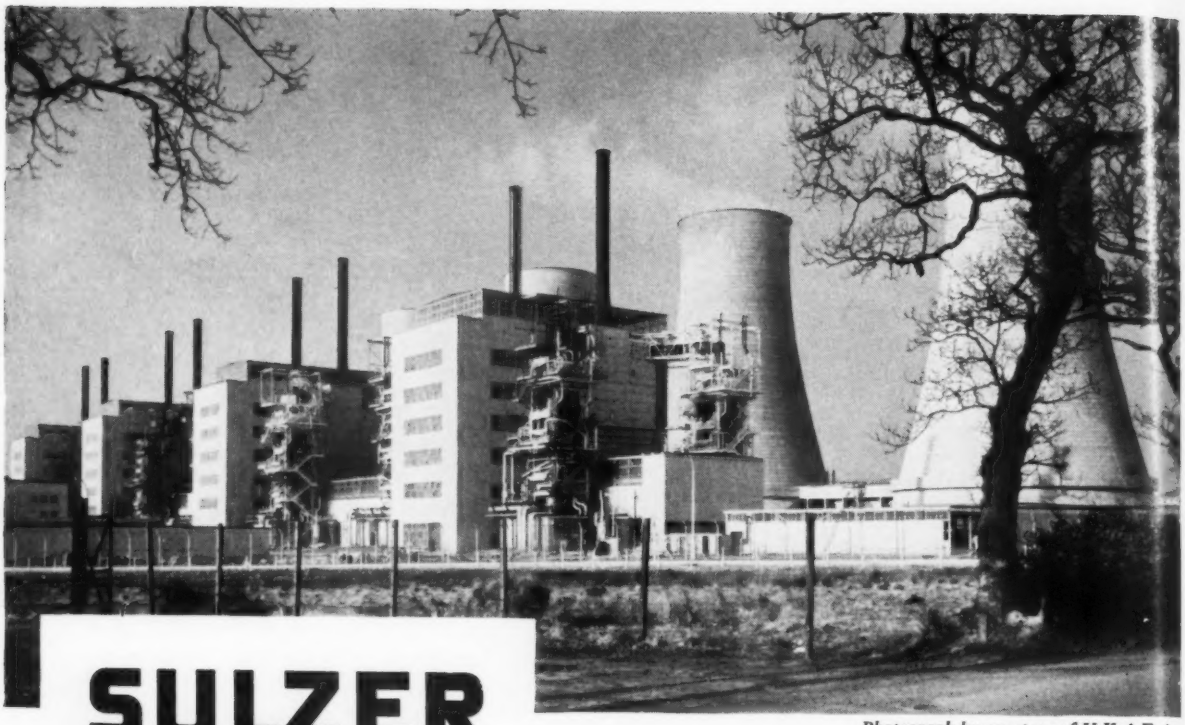

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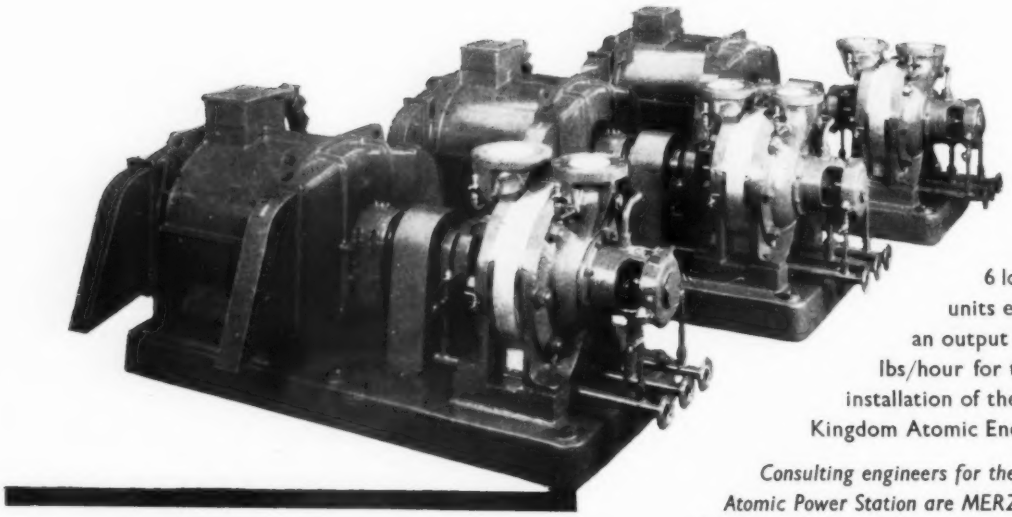

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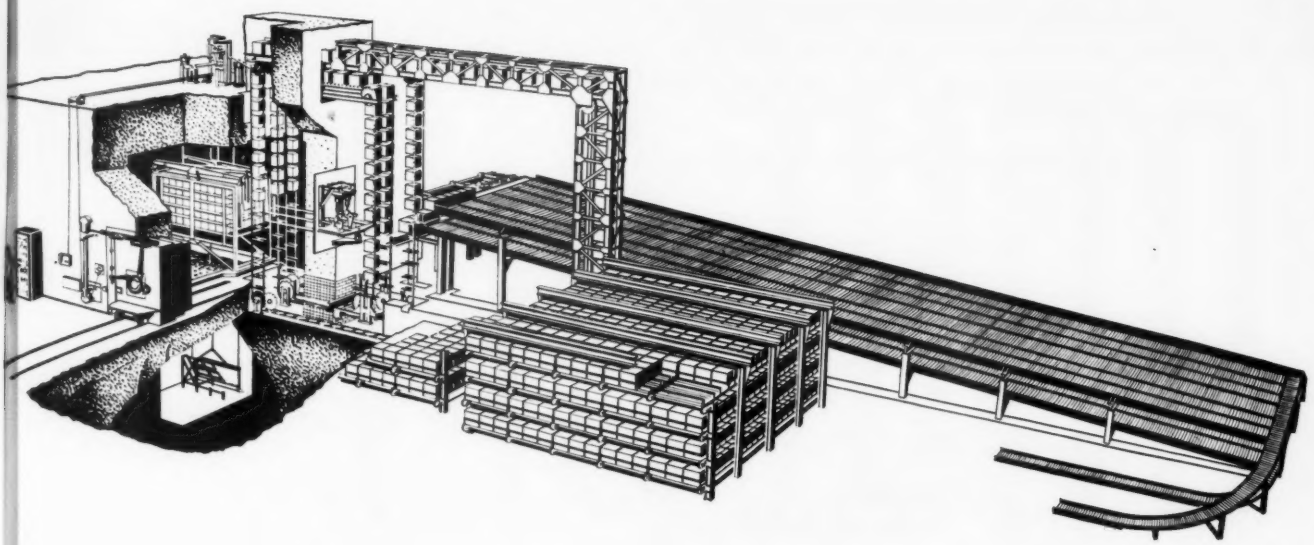

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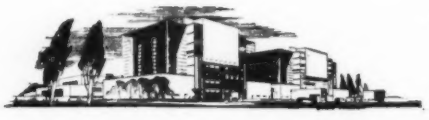

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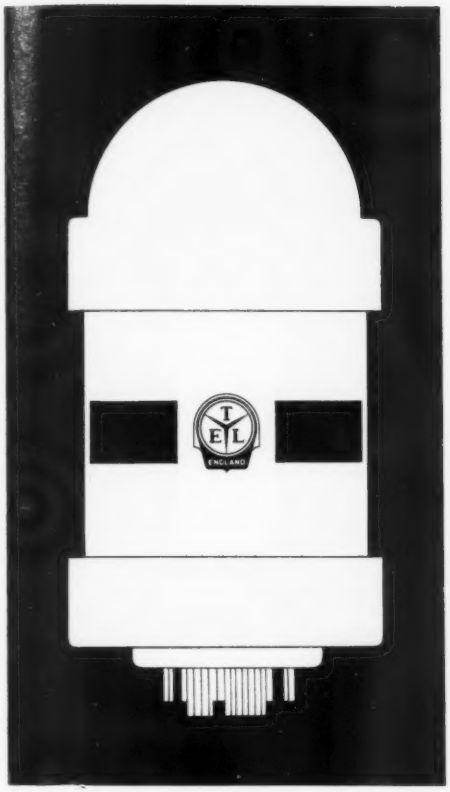

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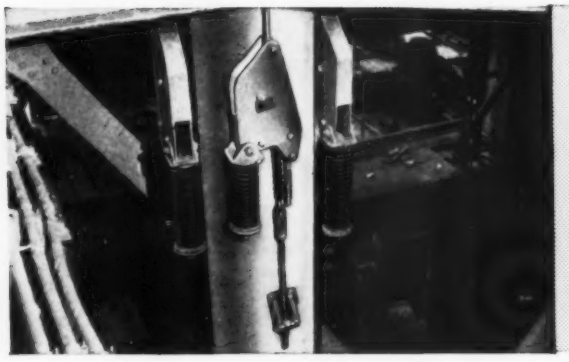

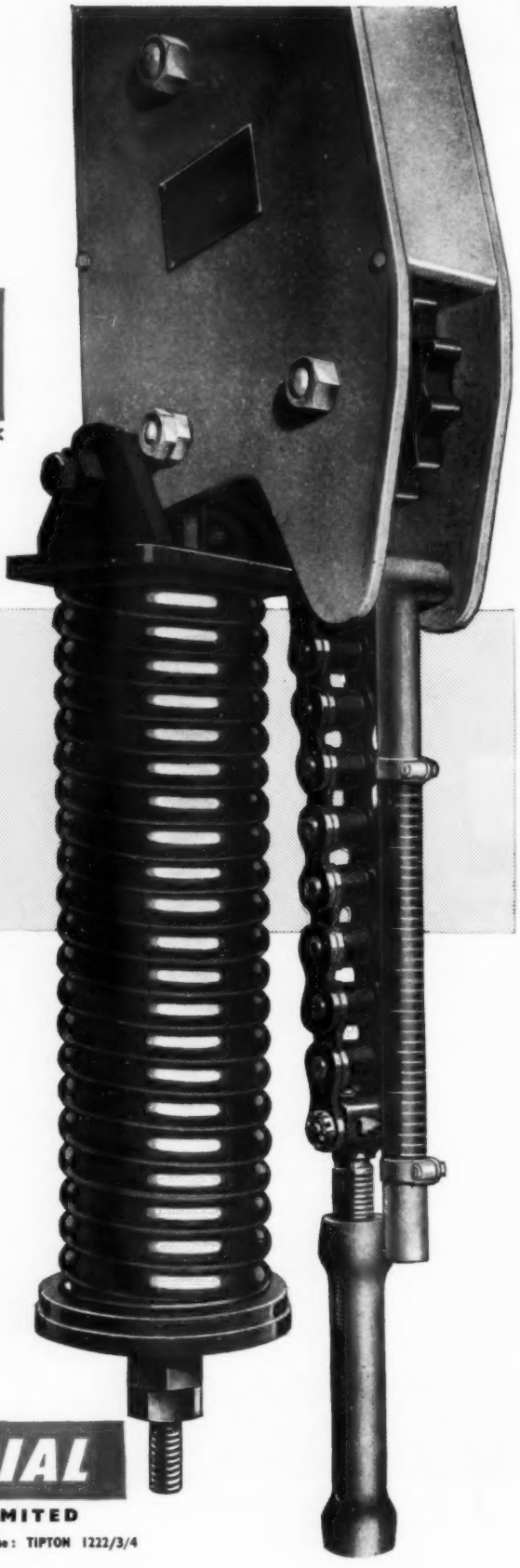

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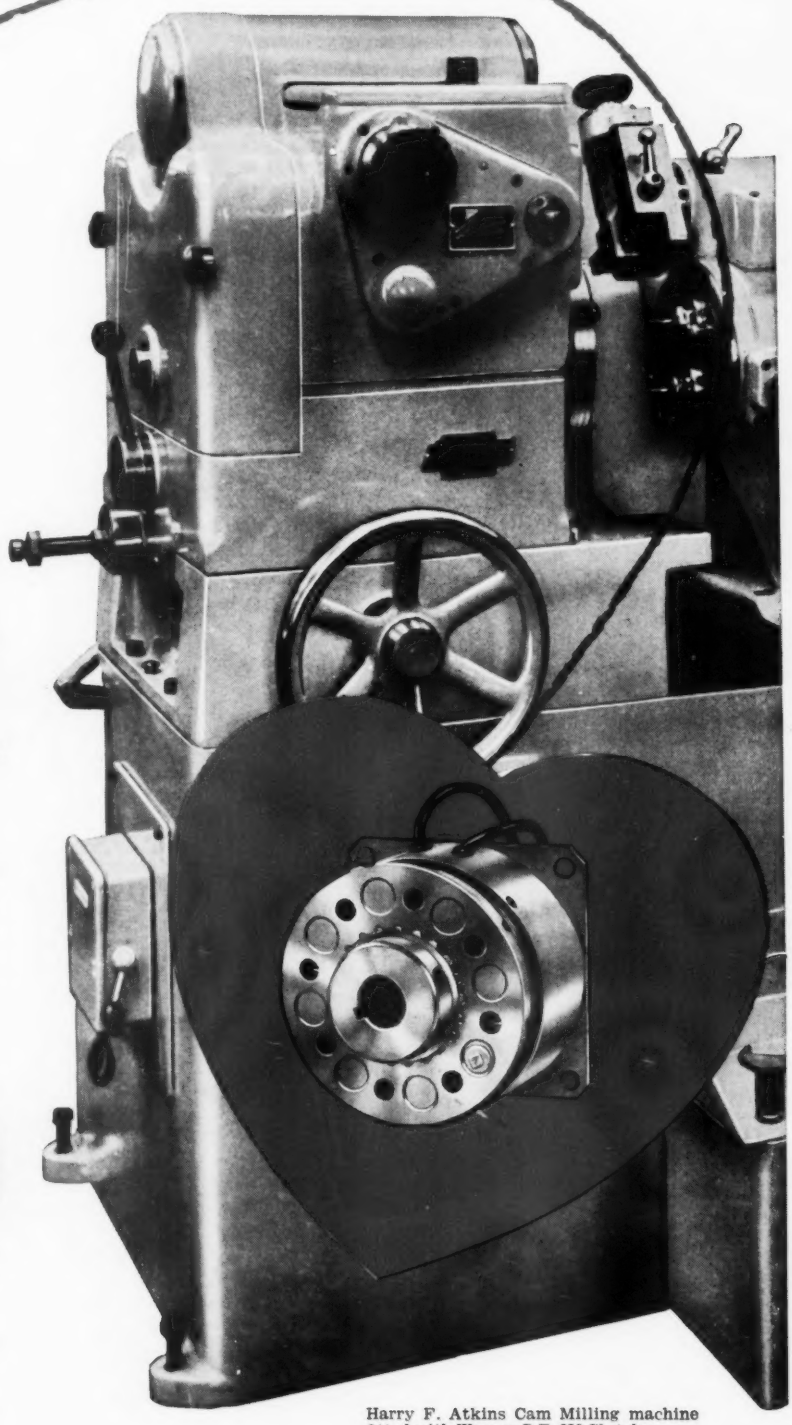

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Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

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The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

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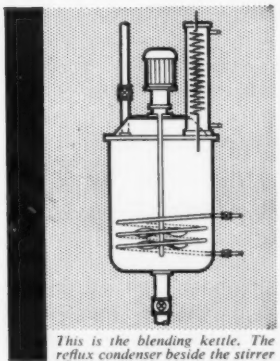

This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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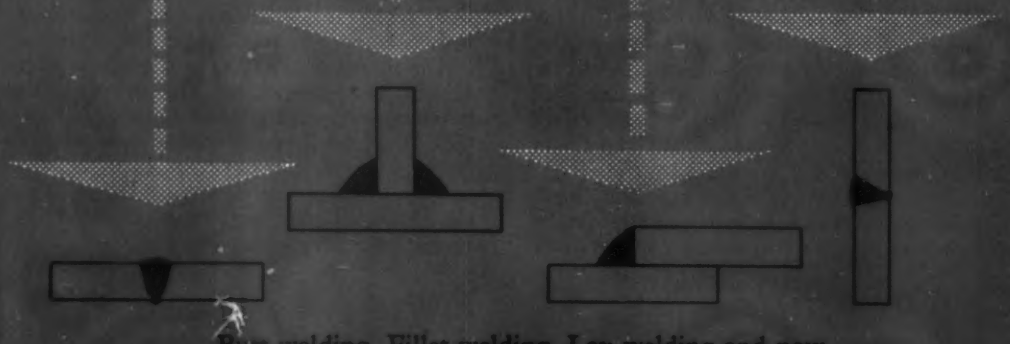

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Light alloys in all wrought forms

The large scale production of the special magnesium alloy used to make the fuel element cans for Calder Hall was the result of collaborative experimental work by Birmetals Limited and the United Kingdom Atomic Energy Authority.

Similar collaboration between Birmetals, the U.K.A.E.A. and the commercial constructors of nuclear power plants is ensuring continued development in this and other allied metallurgical fields.

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM 271

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IN THE MAKING

In common with other Worthington-Simpson products, our condensing plant is manufactured with precision from the highest quality materials and is designed to give long and reliable service.

Specialists in the Worthington-Simpson organisation deal with all problems of heat exchange. We have considerable experience in producing condensing plant for high vacua and feed systems operating at the highest pressures and temperatures.

Complete systems are designed, manufactured, erected and installed, including auxiliary plant—condensers, air ejectors, feed heaters, evaporators, de-aerators, fuel oil heaters, and water coolers for both land and marine installations.

Worthington - Simpson Ltd.

NEWARK NOTTS

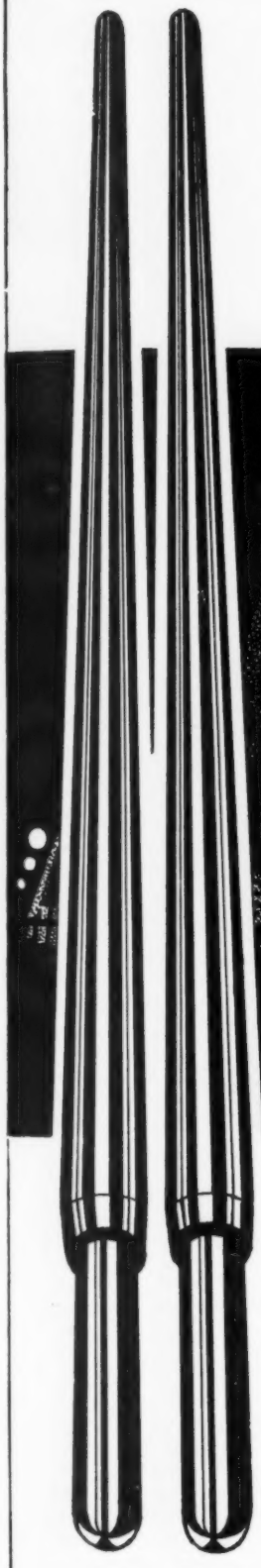
WS

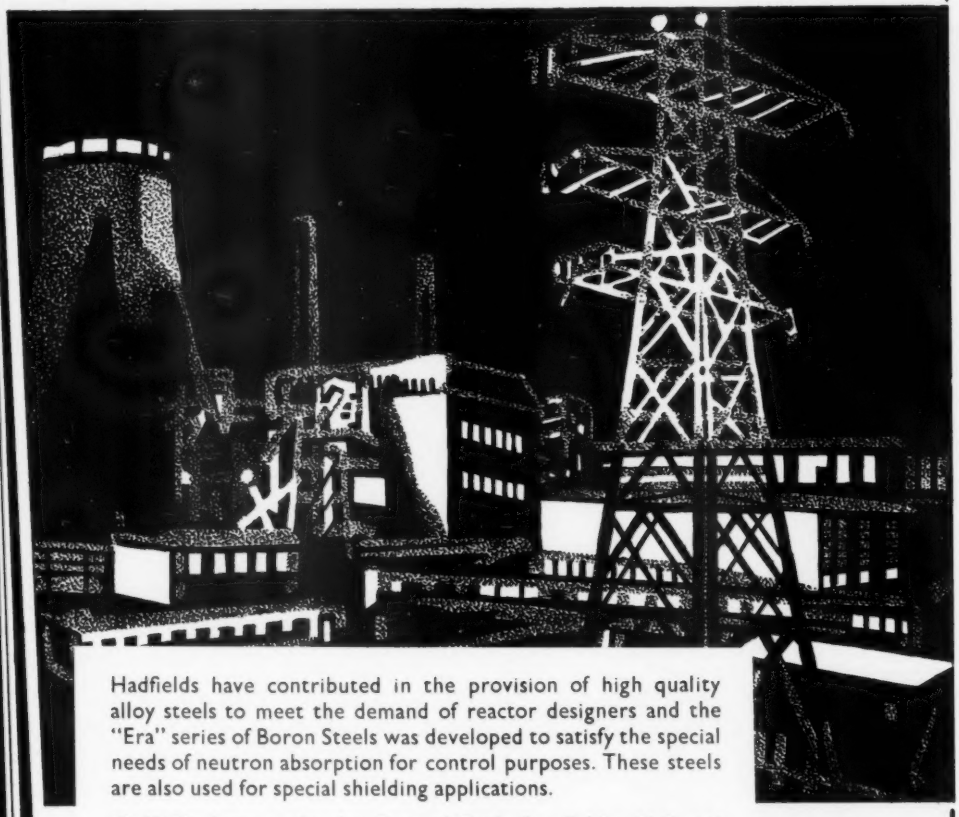
PUMPS · COMPRESSORS · HEAT EXCHANGE EQUIPMENT

P.4229

SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated





Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

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Safe

Conduct

A PLESSIFLEX application on the Bristol Bloodhound

Tough, flexible, seamless, all-metal PLESSIFLEX is the most thoroughly reliable means of conveying fuels and chemicals—whether they are gases or liquids, very hot or very cold, corrosive or inflammable—from one place to another. And this point is overwhelmingly endorsed by engineers in the aeronautical, nuclear, marine and chemical industries.

At pulsing pressures, at high pressures or under vacuum conditions, PLESSIFLEX provides the vital link between those parts in your installations which are subject to continual relative movement.

The basic components of PLESSIFLEX are the result of continuous development and testing, in consequence of which the complete hose units are unrivalled in their high quality. Offered in a range of sizes from $\frac{1}{8}$" to $2\frac{1}{2}$" bore, and in almost any metal you care to name, PLESSIFLEX may be tailored to *your* particular requirements.
Suitably braided for stability, the tube itself is made from material that has been subjected to rigorous pre-process analysis—everything in fact about this versatile, incredibly robust product is shaped to the ends of higher performance and greater safety in fields where such requirements are essential.

Our engineers are waiting to show you how PLESSIFLEX

Regd. Trade Mark

can solve **your** piping problems

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PAL14c

Nuclear Power
REACTORS MATERIALS INSTRUMENTATION PROCESSES IRRADIATION

FEBRUARY 1960 VOLUME 5 NUMBER 46

VIEWPOINTS *letters to the Editor*

Export opportunity in Italy

SIR: In the course of a recent visit to Italy I received the impression that too little attention has been paid there to the various marine reactor projects being evolved in the United Kingdom which are bound in the near future to materialize in one or more prototypes of small capacity. Such reactors may be suitable not only for marine propulsion but also for generating electricity in a land-based power station. This prototype should prove its economic value in Italy sooner than elsewhere for the following reasons: (1) The installation of a small capacity power station in a locality not served by the Italian national grid, in the backward areas of the South, would easily find a base load in land reclamation, irrigation, drilling for water, oil and other minerals, industrialization, public works and utility services, without interference with the grid or commitment to maintenance expenses over large areas and difficult ground; (2) The small capital investment initially required would make it possible to develop a gradual scheme in which various types of reactor, carefully selected, could be tried with very great advantage to nuclear technology both for the exporting country—in this case Britain—and for Italy, where the opportunities for would-be nuclear physicists and technologists are small and the nuclear equipment of the Universities is notoriously inadequate. (3) Low industrial costs, remunerative power prices, capital revaluation of the sites and their surroundings will allow balance-sheets to be based on quite different standards (and more favourable ones) than of any similar undertaking in an intensely industrialized area.

There is no *prima facie* reason why the Italian Government should not associate itself with a programme of this kind, and even the powerful electrical industries in Italy might lend their know-how and their technical and financial resources (in agreement perhaps with the Italian shipbuilders and shipowners).

What is needed is a new outlook from the atomic industry in the U.K. The will to export must prevail over the mere wish to export. You must know your customer's requirements and possibilities if you want to gain a permanent foothold in his market. Italy has entered too late in the atomic field to go it all alone. She needs some reasonable assurances on the reactor performance because she does not know enough about the techniques now being evolved elsewhere. But on the other hand she can offer an extremely useful working ground for the development of small reactors, with economic results just as striking at those which have been achieved already in Sicily—and are now to be expected in Sardinia—through conventional methods.

The opportunity is there now. In a few years' time, when the work of economic development in Italy has entered more definite channels it will be too late. And by then, perhaps old and new competitors of the British atomic industry will have scored a success which might be a resounding and decisive one for a young industry which aims at world markets and needs to gain world-wide prestige.

Wembly, Middx ALDO CASSUTO

Canada's nuclear programme

SIR: Surely the premise in the first sentence of the section on Canada in the very valuable article on National Programmes in 1959 in your January issue [*that Canada has a long way to go before nuclear power is economically competitive*] is quite irrelevant to the stated conclusion [*that Canada has a promising nuclear power programme*]. While this irrelevance does not necessarily invalidate the conclusion it is nevertheless apparent, from a correct statement of the problem, that the conclusion is unjustified.

The problem before the nuclear engineer is not simply to provide energy sources that can compete with existing sources: it is to provide new sources, where they are needed, in competition with other means of providing them. The situation is that the demand for new sources of energy is now being satisfied, in some parts of the country, by coal fired thermal stations. The problem before the Canadian nuclear engineer is thus similar to that posed in some other highly industrialized countries. One would then conclude that the distance to be travelled before nuclear energy can compete economically would, other things being equal, also be similar.

Atomic Energy of Canada Limited H. H. CLAYTON

PUBLISHER'S COLUMN

A New Feature

Many of the scientists, technologists and managers now closely associated with atomic energy, only entered the field a year or two ago. At the same time there is a constant stream of embryo engineers and physicists leaving universities and technical colleges with the aim of making their careers in the new industry. To any of these people a regular reading of NUCLEAR POWER will, of course, be extremely useful, but we decided recently to start a new feature specifically designed to act as a guide to the courses available on different branches of atomic engineering, to the best introductory books on selected subjects, and to indicate what is going on in the world of training for atomic energy. We hope that technicians already established in the industry will also find the feature useful because many new terms and ideas are now current and though, for example, a young instrumentation man may be able to get along without knowing what a barn is, a knowledge of this and other basic principles will give him a much broader view. We are, therefore, including short articles designed to give a simple explanation of basic techniques for those who, as yet, may find the main articles in the magazine rather heavy going.

nucleol

radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission.

This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G 120 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels

A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

OPINION

Men and manpower

WE HAVE to look at two important factors in this country that could easily upset the present delicate balance of achievements. One is the avoidance of prolonged labour troubles that not only cause capital costs to soar but, what is equally important, lose us the confidence of potential foreign customers. The other is the assurance that sufficient scientists and engineers are produced by the universities and institutions to sustain necessary research and development projects, effort that will enable this country to keep its lead in atomic energy.

Labour problems have particularly plagued the construction of civil nuclear power stations, especially Hunterston. Apart from the prolonged suspension of operations by the Motherwell Bridge and Engineering Company that lasted from September 25 until a few weeks ago, a further 100,000 man-hours were previously lost from July 1958 to September 1959. This loss of time has cost the G.E.C.-Simon Carves Group over a million pounds and the South of Scotland Electricity Board some three million. The other three stations have had their share of labour trouble, but none of them have been so badly affected as Hunterston where work is more than a year behind.

The construction pattern of a nuclear power station is not generally appreciated. The number of workers employed on a typical site can reach three thousand representing seventy or more contracting firms and some forty trade unions. Whenever a wage dispute or labour problem is raised it is referred to headquarters, often many miles away. The issues involved become more complex when they involve more than one union or employer. Existing negotiating machinery then functions at an even slower rate and this is the main cause of unrest.

Whether or not claims for higher pay are justifiable is not for us to say, but it is apparent that these labour problems must be solved. The construction schedules for a nuclear station are intricately calculated and a withdrawal of labour at any one point puts the whole programme out of phase. The attitude of a great number of employers to site work, therefore, will have to be completely revised. Locations should be regarded as factory units equipped with the same administrative machinery that is normally available for examining locally the whole gamut of daily complaints and grievances. With this in mind, it is very encouraging to see that the Atomic Power Construction Company have anticipated the problem by appointing Mr. Alfred Robens, the Labour Party's 'shadow' Minister of Labour, to act as labour consultant. His task in resolving the many problems that exist is an extremely difficult one and we will watch with interest future developments in this direction. APC, whilst not a direct employer of labour, are determined that every possible step is taken to avoid trouble on a site equally as remote and difficult as Hunterston.

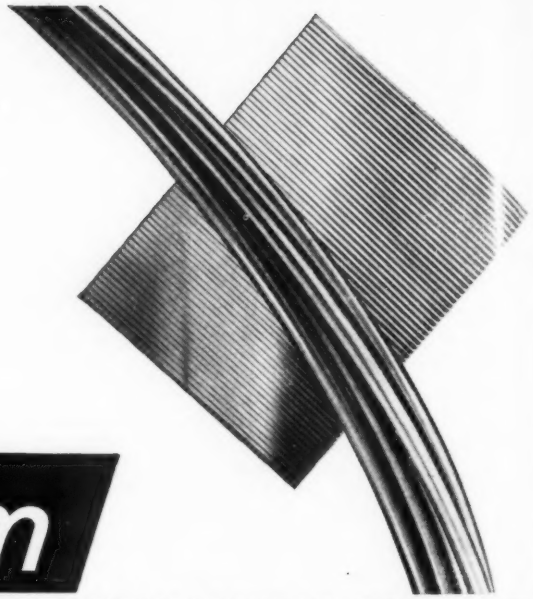
Recruitment roundabout

A steadily increasing proportion of qualified scientists and engineers is essential if our lead in industry is to be maintained and it is encouraging to learn that the recent growth in employment of scientists and engineers, particularly in industry, has been at a rather higher rate than expected (Command Paper 902), and the demand shows no sign of abating. Nevertheless, after allowing for replacement of wastage, the total numbers coming forward over the next three years are still likely to fall short of employers' needs, particularly for civil and electrical engineers, mathematicians, physicists and chemists. With an extension of research and development work in the so-called 'modern' industries, it is not surprising to find that the proportion of qualified research and development workers to those engaged on other scientific and engineering work is as high as 60%; and present demand continues and appears to be insatiable. Recruitment of new staff has reached the stage where rival firms hold interviews practically on each other's doorstep and those employers not in such a strong position as others, are unable to compete for the qualified people they would like to have. This extensive drive to fill vacancies has the unfortunate effect of encouraging many inexperienced applicants, people who would be well advised to gain worth-while experience by staying in their present posts for a longer period.

Although the number of scientists and engineers graduating or being admitted to professional institutions have substantially increased, and considerable numbers will emerge in the future with the Diploma in Technology, demand for people in the higher IQ bracket will exceed supply for some years to come. What then is the answer to this persistent shortage of qualified men and women? From a national point of view, duplication of scientific and engineering effort is costly and wasteful of manpower; the pooling of resources and regular exchange of information, therefore, by companies with large research and development effort would be a welcome step. An increasing amount of work could be entrusted to industry by government research departments and public authorities, especially the Atomic Energy Authority, with the net result of reducing the size of establishments and creating a surplus of scientists that could be readily absorbed in industry.

Zirconium offers a combination of useful properties very attractive to the nuclear engineer.

With high mechanical strength, low neutron absorption and good compatibility with uranium as natural assets, zirconium can be alloyed to provide in addition good corrosion resistance to water at high temperatures, or to carbon dioxide.



Zirconium

THE SPECIALIST'S ANSWER TO A SPECIALIST'S PROBLEM

I.C.I. Metals Division, intimately concerned with the metallurgical problems of nuclear engineering since the inception of the industry, is Britain's largest producer of wrought zirconium.

I.C.I. Zirconium will be used for fuel element support brackets in Berkeley Nuclear Power Station

ICI METALS DIVISION

first in nuclear metals

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON S.W.1.

N.C.2/0

Worldview

the month in atomic energy

Consortia amalgamate

Following negotiations over the past five months between The Nuclear Power Plant Co. Ltd. and the AEI-John Thompson Nuclear Energy Co. Ltd. the two companies have agreed to collaborate on nuclear matters (see *Worldview*, September 1959). To implement this arrangement, an equal partnership under the name of The Nuclear Power Group, NPG, has been set up and the staffs merged.

The primary objects of the new group are to assist in the completion of the Berkeley, Bradwell and Latina power stations; undertake the design, development and sale of all types of reactors, nuclear power stations and nuclear units for ship propulsion; carry out research and development and supply components and materials. The chairman of the new group is Viscount Chandos and the vice-chairman is Mr. R. Edwin McAlpine.

New use for Windscale

A new fuel element laboratory is to be installed in the blower houses of Windscale's No. 2 reactor which was shut down in 1957. The facility will handle several thousand fuel elements a year from both experimental reactors and the power stations. Scheduled for completion by the end of the year the installation which will cost nearly £M1, has been designed to permit superficial examination and radiography; sort sound and failed elements; remove fuel rods from sheathing without distortion; take dimensional and density measurements of the rods; and section the cans and rods for metallurgical examination.

All handling and work on the elements will be carried out by remote controlled machinery which can be rearranged or replaced after becoming decontaminated without the necessity of personnel entering the working cells.

Power to the grid

During the last few days of December the fourth reactor at Chapelcross achieved criticality. The first power was supplied to the grid from the No. 1 reactor as early as February 1959, and Nos. 2 and 3 have been brought into operation at stages since then. It is anticipated that this last reactor will be completed and fully commissioned in the course of the coming weeks, when the station will be supplying up to 140 MW into the South of Scotland Electricity Board's system (see NUCLEAR POWER, June 1959, pp. 102–111).

Industry's opportunity

A revised preliminary draft of 'Factories (Ionising Radiations) Special Regulations' has been issued by the Ministry of Labour. This follows the original draft issued in July 1957, and now has taken into account the recommendations of the International Commission on Radiological Protection and many observations from British industry. Comments on the new proposals are sought by the Ministry of Labour and should be submitted by April 15, 1960.

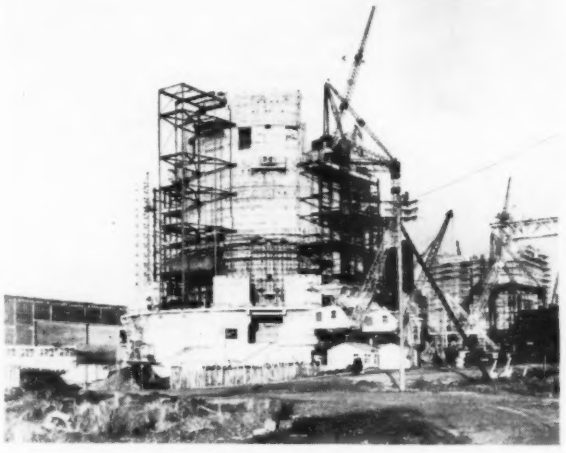
These 196 new regulations are, it is proposed, to apply to all establishments legally classified as factories, where sealed sources are made or used and where X-ray machines, any machines producing ionizing radiations or any machine in which electrons are accelerated by a voltage of not less than five kilovolts are installed.

Included in these provisions are tests for personal exposure and medical supervision, examination of personnel and the procedures to be adopted when workers move from one factory to another. Reactor fuel elements are not covered by these regulations nor are ionizing radiations, used for medical purposes in factories or rooms specially set apart.

Further regulations covering the use of 'open sources' of ionizing radiations in factories are now being drafted.

Another piece of legislature shortly to come into force is that under the Nuclear Installations (Licensing and Insurance) Act, which will be effective from April 1, 1960. Under this (see *Licensing and insuring nuclear plant*, NUCLEAR POWER, September 1959, pp. 93 and 94) operators of reactors have to have a £M5 third party insurance coverage and the British Insurance (Atomic Energy) Committee which represents the insurance companies and Lloyd's underwriters are prepared to give the necessary cover and have, in fact, already provided insurance for a number of UK and overseas reactors.

CONTRACT SIGNED Mr. D. Yasukawa of the Japan Atomic Power Co. shakes hands with Mr. R. N. Millar of The General Electric Co. Ltd. after concluding recently the £M20 contract for the 150 MW GCR at Tokai Mura (see Worldbriefs, last month). Construction, for which a new company, the British General Electric Co. of Japan, has been formed, has now started and is scheduled to be completed in 1964



ALL AT WORK Despite the stoppage on Hunterston's reactor pressure vessels and steam-raising units for some four months due to labour disputes, rephasing of the overall programme enabled work on the rest of the station to continue. Full work has now been resumed but the station will come into operation a year late

NEW YEAR HONOURS

BARON

Sir George Horatio Nelson—Chairman of English Electric Co. Ltd.

KNIGHTS BACHELOR

Joseph Flairith Lockwood—Chairman of E.M.I. Ltd.

Harrie Stewart Wilson Massey—Quain Professor of Physics, University College, London.

ORDER OF THE BATH—CIVIL DIVISION

Sir Roger Mellor Makins—Chairman of the United Kingdom Atomic Energy Authority (G.C.B.).

E. J. Michaels—Under Secretary, Office of Minister for Science (C.B.).

R. N. Quirk—Under Secretary, Office of Minister for Science (C.B.).

ORDER OF THE BRITISH EMPIRE

L. J. Davies—Director of Research & Education, British Thomson-Houston Co. Ltd. (C.B.E.).

D. D. Cruikshank—General Manager, Renfrew, Dalmuir & Dumbarton Works of Babcock & Wilcox Ltd. (C.B.E.).

T. Barlow—Resident Engineer, Windscale Works, UKAEA (O.B.E.).

E. T. Wilkins—Principal Scientific Officer, DSIR (O.B.E.).

H. W. Atkinson—Senior Executive Officer, NPL, DSIR (M.B.E.).

Miss A. Mitchell—Group Labour Manager, Risley, UKAEA (M.B.E.).

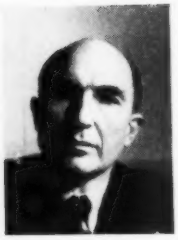
G. H. Prince—Head of Apparatus Engineering Dept., Ericsson Telephones Ltd. (M.B.E.).

J. H. W. Simmons—Senior Principal Scientist, AERE, Harwell (M.B.E.).

J. Ramage—Process Superintendent, Capenhurst Works, UKAEA (B.E.M.).

G. B. Richardson—Welder, Ashmore, Benson, Pease & Co. Ltd. (B.E.M.).

G. H. NELSON
—Baron



R. M. MAKINS
—G.C.B.

L. J. DAVIES
—C.B.E.

T. BARLOW
—O.B.E.

Miss A. MITCHELL
—M.B.E.

J. RAMAGE
—B.E.M.

INTERNATIONAL

Russian hopes

London—During January a group of four scientists, members of the Soviet Fast Reactor Team came to Britain. These were Boris Borisovich Baturov, Engineer of the Department for the Exploitation of Atomic Energy of the USSR, Oleg Dmitrievich Kazachkovskii, Scientific Member of the Fast Neutron Reactor of the Institute of Physics, and Mitya Samuilovic Pinkhasik, Doctor of Plant of the Institute of Physics. During their tour of AEA establishments they went to Dounreay which was a return visit, following the trip to Moscow in July 1959, by a party of scientists from the Dounreay.

Before they returned to Russia, Dr. Kazachkovskii indicated that in addition to the BR-5 facility at Obminsk which is now operating successfully at 5 MW, there were plans in the USSR for larger breeder reactors. At present designs are in hand for a 50 MW BR which will be used to establish economic operating levels and for a 250 MW plant. The larger unit will not be built until more experience has been gained and it can be assured of operating at an economical cost. The future in Russia of the relative number of breeder to other types of reactors will, said Dr. Kazachkovskii, depend entirely on the relative capital and operating costs.

UK gets into Spain

Madrid—An agreement has been signed here by the Spanish Foreign Minister, Señor Castiella and the British Ambassador, Sir Ivo Mallet, covering cooperation in the peaceful uses of atomic energy. This agreement is on the same lines as those between the UK and Italy and the UK and Japan.

The Spanish atomic authorities will now be able to draw on the AEA for assistance in building and operating research and power reactors. It will also enable the AEA to supply fuel and assist in setting up facilities for manufacturing and processing of fuel. Spanish personnel will be trained in Britain under this scheme and it should give the British nuclear industry a chance to get into this so far exclusively American market.

US-Euratom snags

Brussels—The Arbeitsgemeinschaft Kernkraftwerke Stuttgart, AKS, have informed the Euratom authorities that they are not now prepared to proceed with their initial proposals to build a reactor under the joint US-Euratom programme. The reason given for this withdrawal is that the Federal German Government guarantee of up to DM100M which the AKS required for the project is now considered to be insufficient and does not cover all eventualities. Unless Euratom can persuade the German government to increase its assistance, it will mean that there will now be only two installations completed in 1963 to qualify for the American aid; these are the Italian Senn plant and the Franco-Belgian 150 MW unit to be built at Chooz, near Givat.

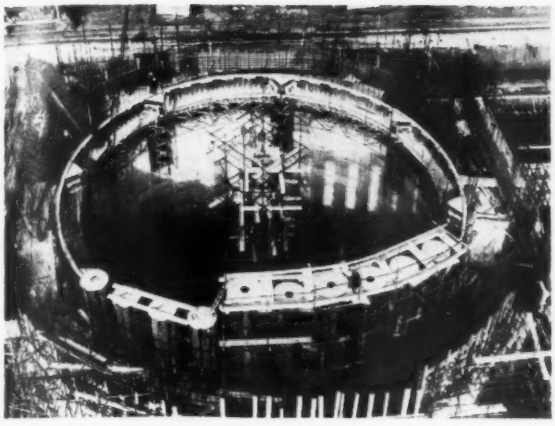
Another power consortium

Canoga Park, Calif.—A joint company to design, build and market nuclear reactors in France and the French Union is to be formed by Atomics International, Société Alsacienne de Constructions Mécaniques and Chantiers de l'Atlantique (Penhoet-Loire). The new company is to be called Dynatom and will give special emphasis to sodium graphite and organic cooled power reactors and solution type research reactors. One of the first proposals will be a 165 MWe OMR for the Société Franco-Belge de Centrale Nucléaire des Ardennes which is a group of French and Belgian utility companies. This project would come within the scope of the US-Euratom joint programme.

Among the French companies in this new organization is the Société Industrielle de Combustible Nucléaire who manufacture the uranium fuel elements for the G1, G2 and G3 reactors at Marcoule and the EDF1 and EDF2 at Chinon. In addition it is anticipated that the two major French members will be appointed by the French Atomic Energy Commission to be the main contractors for the Rhapsodie fast breeder reactor.

Communal research

Brussels—The US-Euratom Joint Research and Development Board have announced that since the first three research contracts were issued in August 1959 (see *Worldview*, September 1959), another twenty such contracts have been awarded and work totalling some $M3½ is now in hand. The Board has mainly



PROGRESS AT LATINA
The reactor diagrid and ring segments (right) are now being fabricated and the biological shield (left) is well above ground level

concentrated its efforts on proposals relating to nuclear fuel cycles and fourteen European and eight American companies and organizations are now participating.

ARGENTINA

Help for South America

Buenos Aires—As soon as the general study of the country's power situation by the International Bank on behalf of the UN Special Fund has been completed, anticipated to be March, an evaluation of nuclear power is to be made. For this purpose an IAEA mission will make a six weeks survey in collaboration with the Argentine Government.

FINLAND

Power in the North

Helsinki—The Finnish Atomic Energy Commission, in cooperation with the country's largest power undertaking, the Imatran Voima O/Y, has established a study group for nuclear power. For this work the IAEA is providing a project officer to act as a special assistant to the group and it is anticipated that another two experts will join in the early work. One Agency official will cover nuclear power economics and the other will deal with the operational features of a suitable plant. The overall study is expected to be completed in about four months.

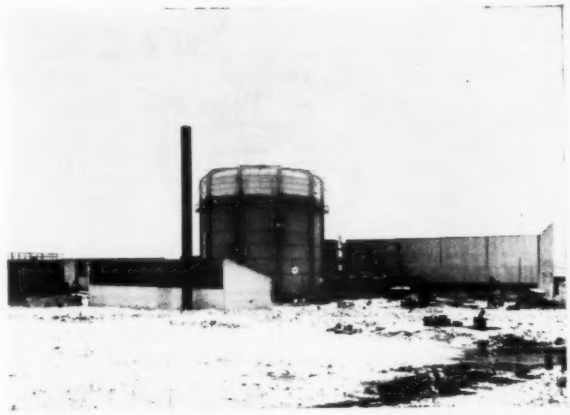
UNITED STATES

Small power plants wanted

Washington—The Atomic Energy Commission has invited proposals for two prototype power plants. These will form part of AEC's power demonstration reactor programme and each will have a minimum output of 50 MWe. One will be a BWR and the other an OMR. The former, to be designated Improved Cycle Boiling Water Reactor, ICBWR, will eliminate the engineering complexity of the dual cycle system and will include the ability to respond, in operation, in direct proportion to the power demand.

The organic-cooled and moderated prototype which is to operate with forced convection cooling has been designed to produce steam at 600°F or higher from the organic coolant. The use of improved fuel, such as uranium oxide clad with sintered aluminium powder, is expected to increase the permissible fuel surface temperature and fuel burnup. If no acceptable proposals are submitted, the Commission intends to go ahead with the construction of these two plants on its own account.

In response to another AEC request for proposals to operate a 60 MWt (22 MWe) PWR power plant, five organizations have responded. The proposals came from the cities of Miamisburg, Ohio; Detroit, Michigan; Fort Pierce, Florida; and Jamestown, New York; and from the Dairyland Power Cooperative, La Crosse, Wisconsin. Under the terms of this project, the operating organization will have to contribute the site, turbogenerating facilities, associated buildings and operate the plant. Construction is expected to start late in June 1960, with completion date scheduled for August 1962.



DENMARK'S THIRD REACTOR
On January 17 the 10 MW DR3 at Risø achieved criticality on schedule

TALKING ABOUT SHIPS The Japan Nuclear Ship Mission, led by Mr. Toshiki Sakurai, President of Mitsubishi Nippon Heavy Industries Ltd., has recently visited government establishments and industrial groups in the US and Europe and is seen here at the Westinghouse Atomic Power Dept. During discussions with AEA, doubts were expressed by the Authority on Japan's proposed small experimental vessel (see 'Prospects for nuclear powered ships', NUCLEAR POWER, January, pp. 108–110) because of comparatively limited collision protection afforded the reactor

Stepping up research

Albany—Determined to encourage joint development by private companies and the State of New York, a committee of the State Power Authority advocates 'aggressive' research for competitive nuclear power and intensification in the pooling of power sources. An initial step in this direction is the establishment of the Western New York Nuclear Research Centre at the University of Buffalo. This facility, estimated to cost $M2, will have

a light-water pool-type 1 MW reactor, to be built by AMF Atomics. In addition, this establishment will house two particle accelerators, radiation laboratory, offices and machine shop facilities. Construction of the Centre, already under way, is scheduled for completion in 1961. When finished, this facility will be owned and operated on a financially self-supporting basis by a non-profit making corporation, to be formed, to conduct research in the field of nuclear energy, including the health sciences. In all operations, priority will be given to the New York State's requests for facilities and services.

Task force report

Washington—The AEC has issued its report evaluating the sodium, heavy-water reactor concept on the basis of its technical feasibility and its potential for the economical production of electric power. The conclusions reached were that at this stage the potential for the near future does not appear to be promising. A return of 30% efficiency which has been claimed for such a reactor is not a sufficient gain to overcome the risk of marginal reactivity, unreliable or expensive steam generators and lack of confidence in the fuel assembly. The report goes on to say that other natural-uranium reactors, such as the PWR and BWR concepts have reached a stage of development higher than that of the sodium-cooled type.

Power for Puerto Rico

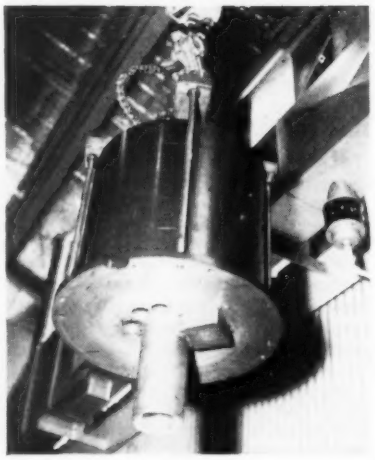
Washington—A contract has been signed by the AEC and the Puerto Rico Water Resources Authority covering the joint participation by both organizations for a small power plant. The reactor will be of the BWR type incorporating nuclear superheating and, fuelled with uranium dioxide, it will provide a net output of 16·3 MWe. Estimated cost of the plant, exclusive of site and power transmission facilities is some $M11.

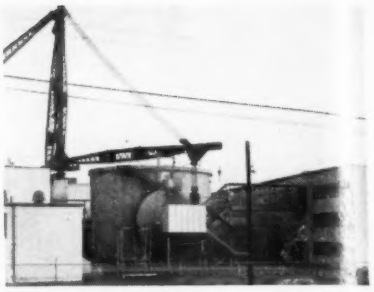
Under the terms of the contract, the Puerto Rican authorities will provide the site and conventional turbogenerating facilities. In addition they will operate and maintain the reactor and purchase the steam from the AEC.

Industry moves ahead

Washington—Apart from the proposals under the AEC's own development programme, the Commission has received an unsolicited joint proposal from the Consumers Power Co. of Jackson, Michigan, and the General Electric Co. of San Jose, California. This project recommends a BWR with an initial output of 50 MWe which would be subsequently developed up to 75 MWe. The proposal provides for the development of fuel elements with long life and low fabrication costs; overall capital costs are estimated to be $M27. If a site is used at Big Rock Point on the shores of Lake Michigan, it is anticipated that the installation could be constructed by late 1962.

NEW FACILITY Removing the top plug (left) of the Argonne Fast Source Reactor, AFSR, which recently went critical. (below) The blanket assembly of five rings of depleted uranium which surrounds the 4½ in. diameter fuel core is lowered into the reactor





LAND BASED SUB The American SIC power plant achieved full power last December. It was designed and developed for the AEC by Combustion Engineering Inc. This complete installation at Windsor, Conn., is the prototype for a unit now being installed in the USS 'Tullibee' scheduled to be launched later this year

WORLDBRIEFS

• **International** The Board of Governors of the IAEA held a ten-day meeting in January. Among the items discussed were requests from Finland and Austria for the Agency to supply enriched uranium.

• **International** The second of two mobile radioisotope laboratories donated to the IAEA by the US has been handed over. It will work in South American countries.

• **International** The Director General of the IAEA has appointed Professor Paulo Ribeiro de Arruda of Brazil as Director of the Agency's Division of Exchange and Training in the Department of Training and Technical Information.

• **United Nations** The 15-member Scientific Committee on the Effects of Atomic Radiation held a two-week session at the end of January and a programme for future work was drawn up. Five specialists have joined the UN Secretariat to act as scientific staff to the Committee.

• **United Nations** Recommendations have been made to the Food and Agriculture Organization and its member governments that greater emphasis should be placed on the importance of agriculture, fisheries and food in determining the 'radioactivity burden of man.'

• **OEEC** The European Nuclear Energy Agency has issued a report 'System of Measurement of Environmental Radioactivity in OEEC Countries, 1959.' This surveys the national monitoring systems and the locations of the permanent stations.

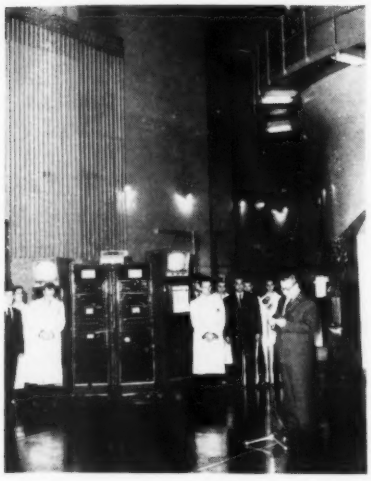
• **Euratom** A recent meeting of the heads of nuclear programmes reviewed the work on non-metallic fuel elements, research on beryllium oxide, pioneer types of slow-neutron reactors and collaboration on heavy-water reactors.

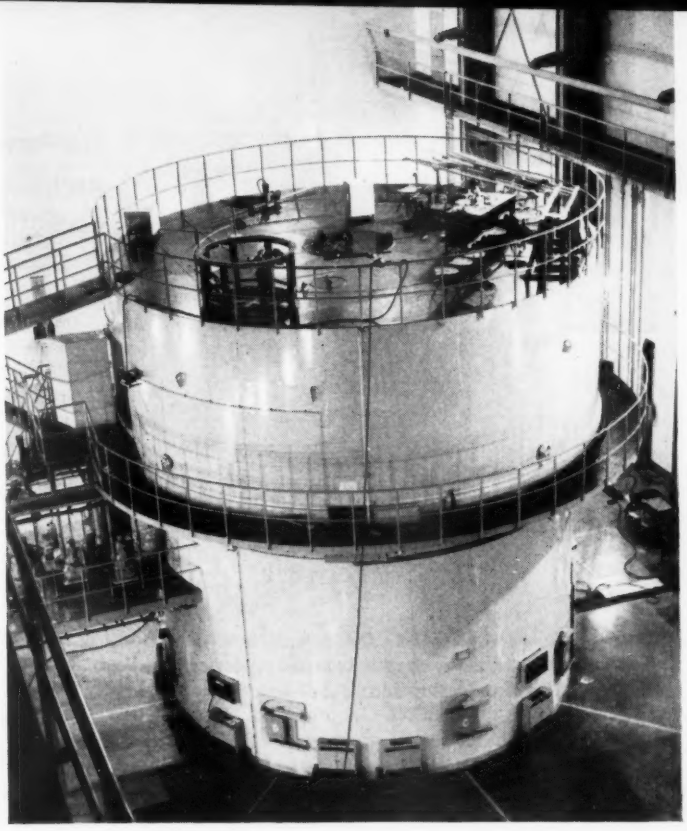
• **Argentina** At the beginning of January, officials of the National Atomic Energy Committee attended the formal opening of a uranium mine, La Primera, situated at Rahueco in the Province of Neuquén.

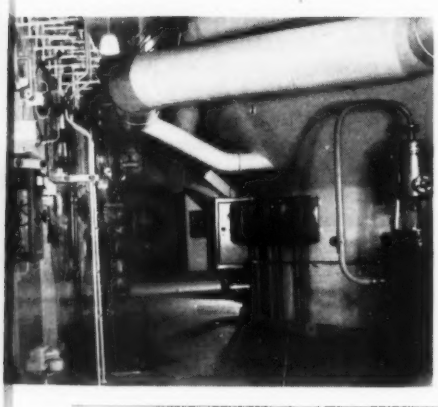
• **Holland** The joint organization of Dutch electricity generating companies

NEW YUGOSLAV REACTOR

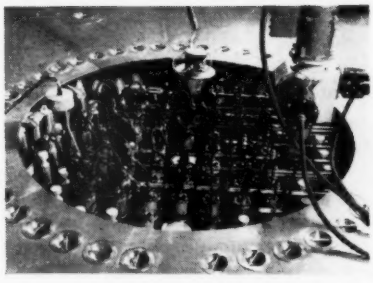
At the Boris Kidric Institute, Vinca, near Belgrade, President Tito, accompanied by Aleksander Rankovic, President of the Federal Commission for Nuclear Energy (below) formally inaugurated on December 28, Yugoslavia's second reactor which is of 10 MWt power







This Russian-sponsored reactor (above) is of the heavy water-moderated graphite-reflected type and is expected to be able to supply all Yugoslavia's isotope needs which up until now have been met by the United Kingdom. The lower portion of the reactor (left) with its D_2O dump and storage tanks bears a strong resemblance to Harwell's Dido. The tops of uranium fuel rods (right) and charging machine, are surrounded by forty-five vertical experimental facilities and in addition there are seven larger horizontal experimental facilities



have decided to postpone their plans to build a nuclear power station; estimated operating costs were too high.

• **India** More than 100 books on atomic energy are featured in the British Council's exhibition at present touring India.

• **Japan** The St. Paul's University, Tokyo, is to have a General Dynamic's Triga reactor; this is a gift from the Episcopal Church in the USA.

• **Philippines** A nuclear power study group has been established to investigate the relative economics and, according to a report of an IAEA mission, there may be a possibility of constructing a plant by 1968.

• **Russia** Another standard Soviet 10 MW research reactor has recently gone critical. This is located at the USSR Academy of Sciences' Physical and Technical Institute in Leningrad.

• **Russia** The icebreaker *Lenin* has now been transferred to the Soviet merchant navy for use in the Arctic.

• **South Korea** Due to meagre fuel resources, consideration is at present being given to the possibility of constructing a 75 MW power plant to come into operation in seven to eight years time.

• **Spain** The first processing plant for uranium-bearing ore came into operation during last December. It is located at Andújar in the Province of Jaén.

• **United States** The Joint Committee on Atomic Energy is to hold an enquiry into the US Army's decision not to proceed with the proposed Ionizing Radiation Centre at Lathrop. It has been suggested that an alternative commercial food-irradiation programme should be initiated.

• **United States** The USS *George Washington*, first of nine nuclear-powered and nuclear-armed submarines, was commissioned on December 30 last.

• **United States** The Homogeneous Reactor Experiment 2, HRE-2, has operated for 100 consecutive days in its most recent test. This test is continuing (see *They said*, this month).

• **United States** The price of helium-3 has been reduced by the AEC from $1·50 to 15 cents per cc. This will enable many more laboratories to carry out nuclear physics research and extremely low temperature investigations.

Du Pont's experience of the dual tempera ure exchange process shows that both capital nd operating costs could be cut in future pl nts

Heavy water production in the USA

by V. R. THAYER, Ph.D.

Director, Chemical Process Section, E. I. du Pont de Nemours & Co.

THE MANUFACTURING facilities at both Dana and Savannah River comprise three separate processes in series. These are (1) hydrogen sulphide (H_2S)—water dual temperature exchange (known as the GS process); (2) distillation of water; and (3) electrolysis of water (*1*), (*2*).

It should be noted that the costly part of extracting heavy water from natural water is involved in concentrating from the natural abundance (about 0·015%) to about 2%. Once this order of concentration has been achieved the rest of the job is relatively easy. The philosophy used in designing the plants, therefore, was to employ the GS process for the first step and to accomplish the final concentration by simpler and more convenient methods, distillation and electrolysis. The actual break point in concentration that was chosen for changing from the GS process to distillation was 15%. With these design criteria about 96% of the investment is in the first step (the GS process).

Soon after heavy hydrogen (deuterium) was discovered in 1931, research workers took advantage of the fact that when water is electrolyzed the hydrogen evolved contains much less than a proportionate amount of deuterium in relation to the water being electrolyzed. Electrolysis entails a high energy consumption but can be operated with a very low in-process inventory. Up until the time that heavy water (D_2O) was produced in quantity, electrolysis was the generally used method for concentrating it. Because of its simplicity and ease of operation, this method was chosen for the 'finishing' step in the heavy water plants. Experience has now shown, however, that it is quite feasible to produce high purity heavy water (99·75% or better) by the distillation step.

Continuous distillation in rectifying columns is a simple and convenient method for separating heavy water from light water. Sub-atmospheric pressures are used to take advantage of the fact that the relative volatility (light water/heavy water) of the two components increases as temperature decreases. The equipment used and the principles of design for continuous distillation are well known in the chemical industry. Although the energy consumption is high, distillation is a feasible process even for a feed stock of natural water. With a feed stock containing 15% heavy water the energy cost of distillation is insignificant compared to the total cost.

Principles of the GS process

The basic element of the GS process is a pair of gas-liquid contacting towers, one of which operates at 30–40°C (the cold tower) and the other at 120–140°C (the hot tower). Water passes downward through the cold tower and then downward through the hot tower, countercurrent to hydrogen sulphide (H_2S) gas at about 275 lb/in² gauge pressure. The gas is circulated by a centrifugal blower that pumps it from the top of the cold tower to the base of the hot tower. The water is progressively enriched in D_2O as it flows through the cold tower, is progressively depleted as it flows through the hot tower, and leaves the hot tower at a concentration lower than that at which it entered the system. Thus heavy water builds up in the system, and can be withdrawn as an enriched fraction from the base of the cold tower (or top of the hot tower).

In practice two or more pairs of towers are connected in series, the second and succeeding pairs being smaller in size than the first pair. This is the well known principle of

BACKGROUND

The dual temperature exchange concept for producing heavy water was studied during the early 1940's in both the UK and the USA by scientists then cooperating on atomic energy. In 1942 the du Pont Company was asked by the US Army to assist the group at Columbia University, where research was centred, in evaluating various processes. Among these was that now known as the GS process, involving the extraction of heavy water from natural water by dual temperature exchange with H_2S. Practical considerations, in particular the shortage of stainless steel, led to the conclusion that the GS process, although inherently attractive as regards energy consumption, was not suitable for use under the existing war conditions.

In 1950 the Company was again asked to assist the US Government in producing heavy water, this time on a much larger scale. In view of the low energy consumption of dual temperature exchange and the improved availability of construction materials, a development programme was organized aimed at translating the conceptual process into an operable manufacturing plant.

Two plants were built and operated: the first was at Dana, Indiana. The second is at the Savannah River (South Carolina) site of the three heavy water moderated test reactors.

cascade design generally used in separating mixtures of isotopes. The arrangement of a Savannah River GS unit is shown in Figure 1.

In addition to the more or less routine problems of tower design and heat recovery characteristic of a large chemical engineering project, there are three major considerations involved in designing a plant for the dual temperature exchange of hydrogen sulphide and water. These are (1) the hazard inherent in handling large quantities of hydrogen sulphide, which is highly toxic; (2) the need to select materials of construction that will be suitable but not unduly expensive; and (3) the requirement for a control system to deal with the unique problem presented by the dual temperature system. It is apparent that the safety of the process is largely dependent upon adequate design as regards materials of construction.

Ferrous metals as construction materials

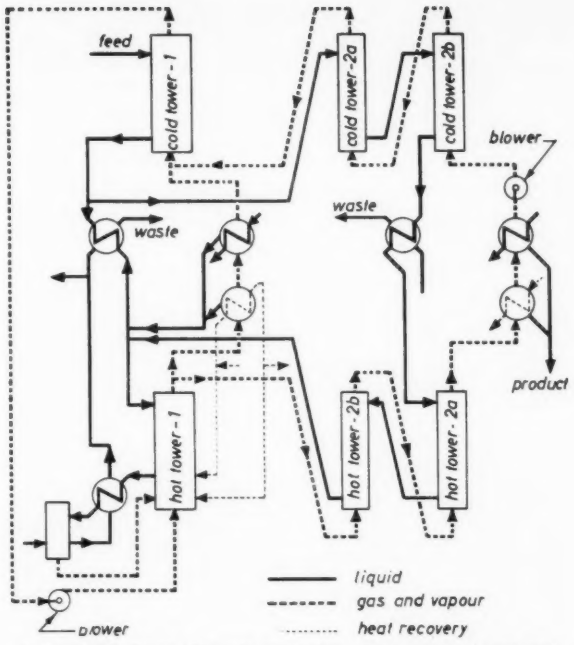
Water solutions of hydrogen sulphide that are handled in the GS process (concentrations up to 4% H_2S by weight) attack steel and other ferrous alloys not only by ordinary surface corrosion but also by blistering and cracking. Practical considerations, however, preclude the use of most if not all materials of construction other than ferrous alloys. Successful design of a GS plant, therefore, requires knowledge of how the ferrous alloys can be used safely. Du Pont experience, based on laboratory, pilot plant, and production plant findings, is as follows:

a. Carbon steel is satisfactory for tower shells, heat exchanger shells, and process piping. Surface corrosion is negligible because under operating conditions a tight protective film of iron sulphide soon covers the steel. A high grade of carbon steel must be used, however, to insure against blistering. Blistering occurs when monatomic hydrogen, formed at the surface of steel by reaction of iron with hydrogen ions, migrates into the metal and then combines to form gas molecules. Combination occurs at voids, slag inclusions, or other discontinuities in the metal. A high grade steel, that had been deoxidized in the molten state by adding silicon (silicon-killed), was used in the heavy water plants to minimize blistering.

b. Tower trays (or other contacting media) should be made from austenitic stainless steel (18 chromium–8 nickel). Carbon steel is unsuitable here because spray impingement prevents a tight iron sulphide layer from forming.

c. Heat exchanger tubes and baffles, centrifugal pumps, and throttle valves are also made of 18–8 stainless steel because they are exposed to erosion either by spray impingement or by high liquid velocity.

d. All ferrous alloys must be suitably heat treated to prevent failure by hydrogen embrittlement (or as the case may be by 'stress corrosion cracking'). Carbon-steel pressure vessels are heat treated as specified by the Boiler Code of the American Institute of Mechanical Engineers. Austenitic stainless steels that have been cold worked during fabrication are quench annealed at 1800–2000°F. Particular care is used in regard to bolts, since those items are in normal practice heat treated to obtain high tensile strength which in turn makes them hard and thus susceptible to stress cracking. To avoid this all bolts used in the heavy water plants are heat treated, after machining, so as to have a hardness not greater than Rockwell C–27, and are installed (using torque wrenches) so that the installed stress is not greater than 40,000 lb/in². It is important to note that flange bolts are vulnerable to attack by small leaks of hydrogen sulphide, and must therefore be treated just as though they were inside the equipment.



A Savannah River GS unit comprises three parts of hot and cold gas–liquid contacting towers arranged in cascade (Fig. 1)

Experience in operating the heavy water plants indicates that carbon steels and stainless steels, properly applied, are quite satisfactory as materials of construction for the GS process.

Unique flow control problem

Although many of the design features of a plant for recovery of heavy water by dual temperature exchange between hydrogen sulphide and water are based upon technology already developed by the chemical industry, the problem of flow control is unique. This point may be illustrated by contrasting dual temperature exchange with continuous rectification. If one is rectifying a mixture of methanol and water, for instance, there is a minimum flow ratio (reflux ratio) required to obtain any specified purity of methanol. If in practice this minimum ratio is exceeded, no harm is done as regards production; the quality of the product is somewhat improved, although the energy consumption is increased. The situation with dual temperature exchange, however, is quite different. In this system there is a single optimum liquid-to-gas flow ratio that must be closely maintained. If during operation this ratio is either increased or decreased by an amount that in distillation practice would be insignificant, the productivity of the dual temperature system drops sharply. In fact, a deviation of 15% either way will reduce productivity to zero. A variation of $\pm 5\%$ is serious, and in order to make the process operate properly, the variation must be held within $\pm 1\%$. This peculiar characteristic of the dual temperature system has been discussed in detail (*1*) and (*2*). It is sufficient to say here that the problem can be seen by inspection of the graphical mass transfer plot (McCabe-Thiele diagram) for a hot tower, cold tower pair.

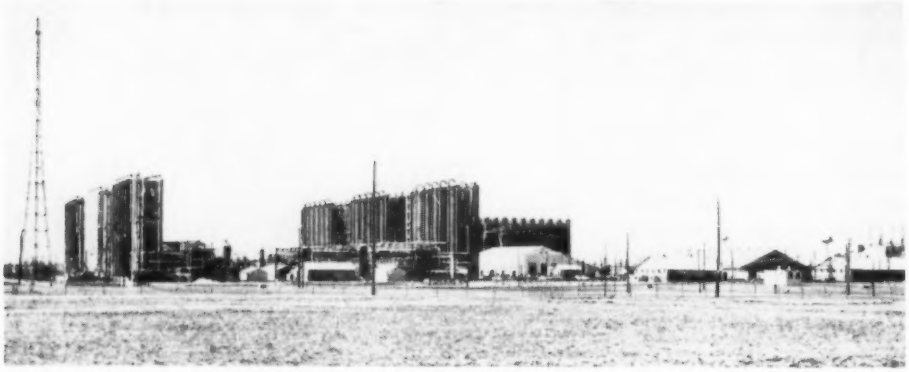
In order to appreciate the importance of the flow control problem, practical experience in the chemical industry is helpful since such experience teaches what can and cannot be

done with meters. In dealing with large flows of water and hydrogen sulphide, orifice meters are used. The absolute accuracy of an orifice meter is relatively poor, probably in normal practice ±10%. Thus, even if the exact liquid-to-gas ratio required for the process is known (a problem in itself considering that this ratio varies with the hot tower temperature, the cold tower temperature, the gas purity and the gas pressure which are also subject to measurement errors), it is not practical, if in fact even possible, to set or measure the ratio on an absolute basis.

taken every two hours and after experience has been gained and operation smoothed out, every eight hours. On the basis of these analyses, flow controllers are reset as necessary.

Design of the heat exchange system

The exchange of heat between hot and cold streams, to minimize the amount of steam that is consumed as make-up heat in the GS process, is a straightforward problem in chemical engineering design, and follows normal practice in the chemical industry. The largest quantity of heat involved



The Dana plant comprises, from left to right, flare tower, south row of GS units, control buildings, north row of three GS units, distilled water towers, service buildings and power house (Fig 2) (*1*)

The solution to the control problem, developed during the operation of our pilot plant, involves the measurement and interpretation of the isotopic concentration gradient in the towers, thus making unnecessary an absolute measurement of either gas flow or liquid flow.

Inspection of the McCabe-Thiele diagram shows that when any deviation from the optimum flow ratio occurs, the concentration gradient moves in one direction in the cold tower and in the opposite direction in the hot tower, the greatest change occurring at the mid-point of each tower. Specifically, a high liquid-to-gas ratio causes heavy water concentration to fall at the mid-point of the cold tower and simultaneously to rise at the mid-point of the hot tower. With a low liquid-to-gas ratio these changes are reversed. By analysing samples taken simultaneously from the mid-points of the two towers, one can tell by inspection whether the liquid-to-gas flow ratio is optimum, high, or low. (It should be noted here that industrial flow controllers used in connexion with orifice meters will maintain the flows steady within ±1% even though the absolute magnitude of these flows is not known. In any event a failure or drift of the meter–controller combination shows up rapidly in the mid-column concentrations.)

To emphasize the importance of this indirect approach to flow control, it may be said that in our opinion the GS process cannot be operated efficiently, if indeed it can be operated at all, by simply setting the calculated flows on meters.

In order to use the mid-column sampling technique, an accurate method of isotopic analysis is required. Analytical methods are discussed in detail in (*2*). The important analytical tool used at the Savannah River heavy water plant is a mass spectrometer (Consolidated No. 21–330) capable of differentiating between a heavy water content of 0·015% (natural water) and 0·016%. (This instrument was made especially for us by the Consolidated Electrodynamics Corporation, based on technical principles suggested by our analytical group.)

During startup of a GS unit, mid-column samples are

is the heat of vaporization of the water component (humidity) of gas leaving the top of the hot tower. This heat is used to humidify gas entering the base of the hot tower, by a combination of direct and indirect heat exchange (Figure 1). This heat saving arrangement is identical to that used in the synthetic ammonia industry in connexion with the 'water gas reaction' (carbon monoxide + water → carbon dioxide + hydrogen). An excess of H_2O (as steam) is required to drive that reaction and the heat content of the product gas is used to humidify the feed gas.

Many variations of the heat exchange system are possible, depending upon steam costs, steam pressure available, types of heat exchange equipment available, and upon the prevailing level of capital charges for heat exchange equipment. It is of interest to note that an arrangement quite similar to that used at Savannah River has been suggested by Dr. Weiss (*3*) of Pintsch Bamag in West Germany.

Production experience and costs

Productivity of the GS units has been increased continuously since startup by continued efforts to improve plant performance. Much higher throughputs of gas and liquid are now carried than were assumed in the original design. The temperature differential between the towers has been increased and the operating continuity substantially improved. Attainable figures for continuity are 96–97% 'time on the line'. Capacity of a Savannah River unit comprising an 11 ft dia cold tower, a 12 ft dia hot tower, and four 6½ ft dia secondary towers has been brought up to about 22½ short tons (2000 lb) per year, compared to the original design rating of 10 tons per year. The Savannah River heavy water plant contains 24 such GS units.

The Savannah River heavy water facility is equivalent in size to a large chemical plant or oil refinery, and comprises, in addition to the production units, all auxiliaries needed to sustain the manufacturing operation. These include a hydrogen sulphide generating plant, power house to supply steam and electricity, river pumps and pipe lines, water

treating system, analytical laboratory, maintenance shops, office buildings, cafeteria, roads, parking lots, guard-houses, boundary fence, etc. The cost of the entire area was $163 million (Table 1). In considering the capital cost of heavy water manufacturing facilities, it should be noted that estimates are sometimes published covering only the manufacturing equipment proper, omitting auxiliaries.

TABLE 1 *Capital Investment in $M*

MANUFACTURING EQUIPMENT PROPER	
GS units and gas generation	113
Water distillation	2·5
Electrolysis	1·5
SUB-TOTAL	117
AUXILIARIES	
Power Plant	31
Water system	8
General facilities (offices, shops, etc.)	7
SUB-TOTAL	46
TOTAL	163

It will be noted that the investment in the GS units is $113 million and in the finishing plants £4 million.

When dealing with investment costs it is convenient to express them on a unit basis. For a total investment at Savannah River (including auxiliaries) of $163 million and a production capacity of about 1 million lb per year, the 'investment per annual pound' of production is $163.

In estimating the cost of producing heavy water, some appropriate charge must be made for the use and recovery of capital, bearing in mind that this charge will vary with circumstances and indeed with the judgment of those supplying the capital. If a heavy water plant were used in support of a nuclear power plant, it might be logical to treat capital charges in the same way as they are treated for the power plant. For instance, capital charges at 10% per annum on an investment of $163 'per annual pound' including auxiliaries would be $16·30 per lb; without auxiliaries, about $12 per lb.

TABLE 2 *Operating Costs per lb of D_2O in $*

DIRECT PRODUCTION COST	
Feed Water	0·40
Hydrogen Sulphide	0·35
TOTAL MATERIALS	0·75
Salaries	0·37
Operating Labour	0·93
Miscellaneous supplies and expenses	0·15
TOTAL DIRECT PRODUCTION COST	2·20
DIRECT MAINTENANCE COST	
Labour	1·32
Material	0·49
TOTAL DIRECT MAINTENANCE COST	1·81
UTILITIES	
Electrical energy	1·33
Steam	4·40
Cooling water	0·12
Miscellaneous	0·06
	5·91
TOTAL DIRECT COST	9·92
ADMINISTRATIVE AND GENERAL EXPENSE (*Overhead*)*	3·49
TOTAL OPERATING COST	13·41
**The principal single items entering into this cost are:*	
Analytical control	0·36
Technical assistance	0·25
Maintenance supervision	0·30
Patrol (guards)	0·31

The remaining overhead costs are widely distributed over administrative and service activities.

TABLE 3 *Essential materials and services per lb D_2O*

Treated feed water	3500 g
Hydrogen sulphide	0·94 lb
Electrical energy	310 kW h
Process steam	5600 lb
Cooling water	12,000 g

The operating cost of making heavy water at Savannah River is about $13 to $14 per lb (Table 2). The total production cost may be derived by adding to the operating cost an appropriate capital charge.

To assist in analysing the operating cost, Table 3 shows average quantities of essential materials and services used to produce one pound of heavy water.

TABLE 4 *Personnel employed*

	SUPERVISORY	NON SUPERVISORY
Operation of process facilities	50	180
Maintenance	48	357
Utilities	14	60
Technical (Plant control and technical assistance)	25	38
Services (medical, patrol, accounting, transportation)	25	114
Administration	8	1
	170	750

Table 4 will give an idea as to the personnel actually employed in a large self-contained heavy water plant such as Dana or Savannah River.

Previous discussion has shown that capital cost is an important or even an over-riding factor in the economics of heavy water production. An important item concerns the tower internals. As previously noted bubble cap trays were used, conforming to standard practice in the American chemical industry. Sieve trays have been tried in the plants experimentally, however, and for this particular service have been shown to have significant advantages. (It should be noted that sieve trays are less flexible than bubble cap trays: they must be operated within a relatively narrow range of liquid and gas flows. This, however, imposes no hardship on the GS process.) It is estimated that the use of sieve trays rather than bubble cap trays in a Savannah River unit, making no other significant design changes, would increase the capacity about 15% and reduce the investment by perhaps 5%, making an over-all reduction in investment per annual pound of about 20%. Operating cost, per pound, would be reduced about 10%, reflecting greater production achieved with no change in personnel.

As previously noted the finishing step can be handled adequately by distillation so that the electrolytic plant would not be required. This would reduce the over-all investment by about 1%, and operating cost by about the same amount.

Acknowledgement

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After several years' work on high temperature problems, the final design of this joint European reactor is now taking shape

THE DRAGON REACTOR
development and design of the HTGC

by G. E. LOCKETT, A.M.I.Mech.E., A.M.I.E.E.
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Head, Materials Branch, Dragon Project

THE PRINCIPAL LIMITATIONS to the further economic development of conventional aqueous and gas-cooled reactors are primarily associated with their low fuel element temperature. This temperature is restricted by irradiation damage and by incompatibility between the coolant and fuel element. The low fuel element temperature gives rise to problems of heat removal resulting in a limited coolant outlet temperature. In the High Temperature Gas-Cooled Reactor an attempt has been made to overcome these fundamental problems by using the moderator (graphite) as the structural material of the core, the fissionable and fertile material in the carbide form (that is in chemical equilibrium with its environment), and by the use of a noble gas (helium) as the coolant. Furthermore, problems of irradiation damage to the moderator and reflector are less serious than in conventional reactors, as the whole core—and the inner ring of reflector graphite—are replaceable. The layout of the reactor is shown in Figure 1.

The use of graphite as the structural material within the core results in structural integrity up to temperatures of at least 2500°C, whilst, with helium as coolant, inherent compatibility problems are avoided. Furthermore, by employing the principle of a dispersed phase fuel element and by using the moderator to extend the heat transfer surface, it is possible to obtain high power densities and high coolant outlet temperatures with relatively low heat transfer coefficients, since an appreciable temperature difference is permissible between the fuel element and the coolant. The chemical reactivity of graphite at high temperatures eliminates—for compatibility reasons—the use of conventional canning procedures, and the Project has accepted from the outset the principle that fission products will be released into the primary circuit.

With the exception of graphite for the fuel elements, no special demands are made on materials, and although high standards are required—for example extreme purity is required in the helium to prevent mass transfer of graphite by oxygen and hydrogen containing impurities, and a very high standard of leak tightness of the primary circuit is necessary to prevent the escape of fission products—the reactor employs conventional materials and methods.

FUEL ELEMENT DEVELOPMENT

Initial thoughts on the fuel element involved the use of graphite in which the uranium was evenly distributed throughout the core by impregnation with uranyl nitrate solution with subsequent conversion of this uranyl nitrate to carbide. However, when it became apparent that no metallic material was satisfactory for canning such a system, the principle of utilizing graphite cans coupled with a fission product control system was adopted. A number of alternatives was considered from which the present basic design of fuel element as shown in Figure 2 was evolved. It was envisaged that the fuel would be within the graphite can and that a flow of helium from the coolant passages through the can wall would be maintained, thus flushing the fission products and preventing their back diffusion into the primary circuit. Calculations showed that with pile graphite, even with the minimum realistic pressure difference between the outer and inner walls of the can, the quantities of coolant passing through the fuel rod cans into the fission product clean-up system was excessive, and that a permeability of at least 100

HISTORY OF THE PROJECT

Early in 1956 a small team was formed under Peter Fortescue at AERE, Harwell, to investigate the possibilities of a high temperature gas-cooled reactor. Although the objective was to carry out a feasibility study of the system as a whole, it soon became apparent that the best approach would be to do a design study of a 10–20 MW reactor experiment. After three years' work, in April 1959 responsibility was handed over to a joint European team to become the OEEC High Temperature Reactor Project — Dragon. Now fifty overseas scientists and engineers are working with UK staff at Winfrith Heath, and construction should begin this year with a finishing date in 1963.

Meanwhile groups in Germany and the USA have also become very interested in the system. A 40 MWe prototype, planned for completion in 1963, was announced in 1959 by the 51-company High Temperature Reactor Development Associates. The design for this is by General Dynamics whose team includes Peter Fortescue, seconded to them in 1957. Two years later he finally severed his connexion with the UKAEA.

Also announced last year, the unique pebble bed 15 MWe experiment to be built at Julich by Krupp/Brown Boveri will be used as experience for a 100 MW plant.

times lower than pile graphite was required. This led to the adoption of Morgan Crucible Company's EY9 graphite for the fuel rod cans.

Impermeable graphite needed

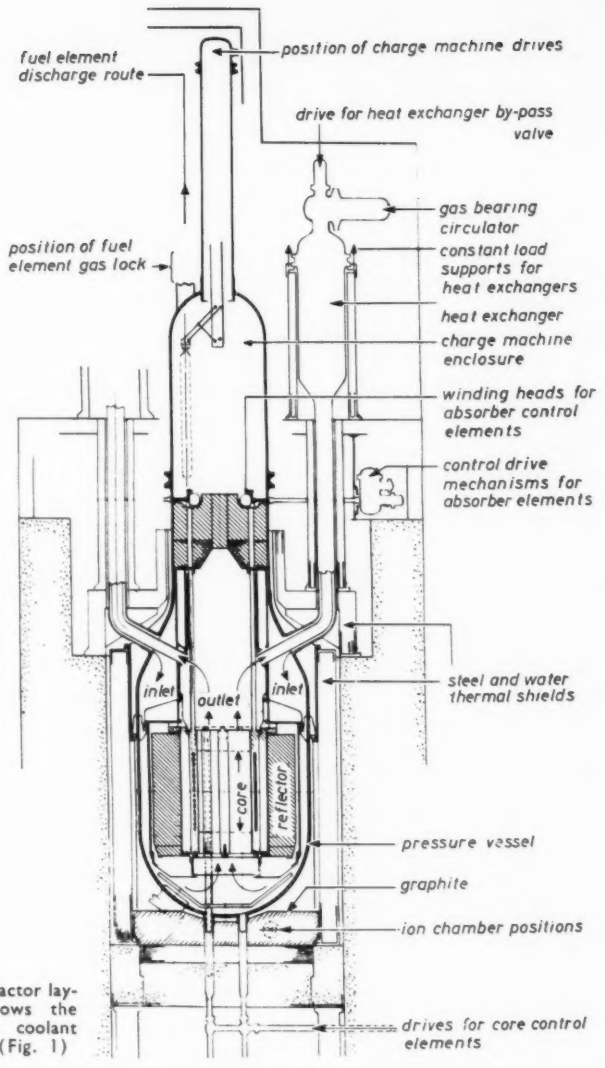
Experiments on the mechanism of gas flow through EY9 showed that the flushing principle of preventing back diffusion of fission products through the can wall would not give the desired results, for, if the pores of the graphite (or of any other material) are of the same order of dimensions as the mean free path of the gas molecules, then the flow becomes 'molecular' rather than 'viscous' and flushing becomes ineffective. With EY9 a significant fraction of the flow is 'molecular' and it was therefore necessary to produce a graphite of sufficiently low permeability to restrict the diffusion of fission products into the primary circuit. Calculation showed that a lowering of the permeability by a factor of at least 1000 was required. This has been achieved by impregnation using furfuryl alcohol.

Preliminary work on this process had been carried out at the Royal Aircraft Establishment (RAE) Farnborough. Considerable further development was necessary, and this has been carried out at the RAE and by the Hawker Siddeley Nuclear Power Co. at Langley. Basically the process* involves three stages: in the first the graphite is impregnated with furfuryl alcohol to which a suitable catalyst, to promote polymerization, has been added; the specimen is then heated to about 300°C to complete polymerization: finally it is heated to 1000°–2000°C to carbonize the resin within the pores of the graphite. By repeating this process with appropriate modifications in technique, it is possible to obtain improvements in permability of the order of 10^6.

With the principle of fission product control accepted, it was desirable to group the fuel rods in clusters of seven to minimize the number of take-off points to the fission product control system. This was achieved by joining the fuel-rod tubes to a top block and bottom block of graphite. The original design is shown in Figure 2a. It consists entirely of graphite: subsequently the method of mounting was modified (see Figure 2b). Spike mounting was chosen so that elements would stand singly and this type of element, using the spike, was the first to be manufactured in graphite.

The main weakness with this type is in the graphite bolts which are necessarily restricted in size, and it soon became apparent that the general handling characteristics of a complete fuel-element assembly were not satisfactory under certain handling attitudes when the bolts could be overloaded.

*Watt *et al* NUCLEAR POWER 1959 (Feb) p. 86



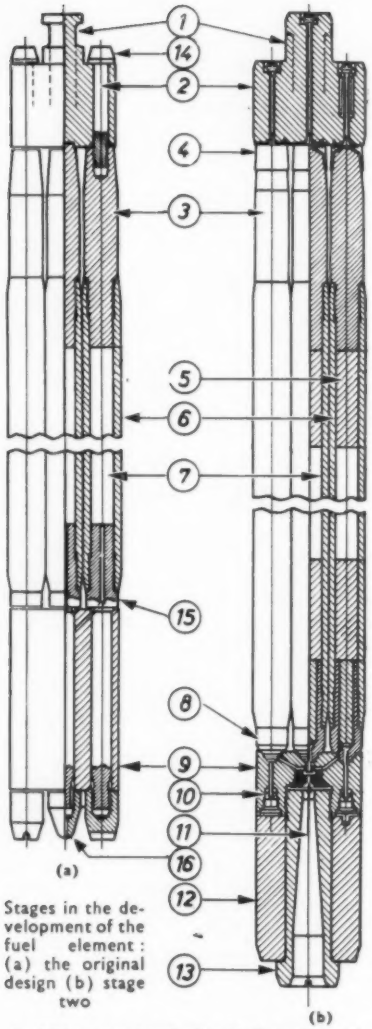
New reactor layout shows the revised coolant flow (Fig. 1)

The final design

The first modifications to the earlier all-graphite design are shown in Figure 2b, in which metal bolts are introduced at positions well clear of the core region where they do not seriously reduce the effectiveness of the end reflector graphite. In all these designs the top block is attached closely to only three of the outer fuel rods, the remaining four fuel rods being positioned but not clamped; this is to accommodate any length differences. It was felt, however, that an allowance should be made for relatively large length changes in any fuel rod during operation. Recent designs have included this modification together with a number of other improvements, and an illustration of the prevailing type is shown in Figure 3.

The top block has been redesigned to permit connexion to all seven fuel rods by a system of diaphragm washers as illustrated in Figure 4. Small manufacturing differences are accommodated by elastic deformation of the diaphragms and, when handling, loads are shared between the rods. Should an appreciable length change of a rod occur during operation, however, the restraining diaphragm will readily yield without introducing serious reaction forces, since the strength of the diaphragm material will be low at the operating temperature of 750°C. The cooling channel shape has also been revised to provide a more uniform heat transfer coefficient over its surface. This is shown in Figure 3.

The bottom end of the fuel element assembly, also shown in Figure 3, has been rearranged to provide an all-



Stages in the development of the fuel element: (a) the original design (b) stage two

1—Lifting extension 2—Top block 3—Top end plug 4—Metal cap bolt 5—Filler piece 6—Fuel rod tube 7—Cavity for fuel sleeves and mounting spines 8—Bottom fuel rod end plug 9—Bottom block 10—Compensating washer 11—Mounting seat 12—Bottom extension block 13—Mounting sleeve with limited clearance over spike 14—Top joint bolts, 3 joining, 3 relieved 15—Combined bottom end plug and joint bolts 16—Mounting seat (Fig. 2)

metal system for attachment to the seven fuel rods. This improves the strength of the mounting system, helps the problem of providing leak-tight passages, and simplifies the attachment of the rods. This arrangement also takes the metal items further away from the core.

A further change is an increase in the fuel rod pitch from 2¼ in. to 2½ in. This follows from a change in core geometry which was introduced to increase the Reynolds Number in the cooling channels. The revised core now consists of 37 fuel element positions, some of which are occupied by special control elements.

In the early designs of fuel elements the fuel inserts were of annular form (1½ in. o.d., 1 in. i.d. by 1 in. high) located on a central graphite spine. They were made by cold compacting uranium metal powder, thorium metal powder and graphite powder, and it was intended that they would react to form carbides within the reactor. This avoids problems associated with the reaction (to form oxides) of thorium carbides and uranium dicarbide with moisture in the atmosphere (c.f. the reaction between calcium carbide and moist air).

Irradiation tests on sections of the fuel element have been carried out in Bepo and Dido at temperatures up to 1000°C and for periods up to one year. These tests have shown that the irradiation stability of the fuel element is excellent: no significant changes in essential properties have been observed. However, to reduce the possibility of fission fragment damage to the inner wall of the fuel rod can and to reduce the activity in the fission product control system, it is proposed to seal the fuel insert assembly in an 'impermeable graphite' box (see Figure 3) approximately 1¾ in. o.d., 1⅝ in. i.d. by 6 in. high. It is hoped that this will provide a delay of at least one hour for all volatile fission products, thus reducing significantly the activity escaping into the fission product control system.

For certain applications of the reactor system, fission product retaining fuel insert assemblies are required, whilst for others various degrees of retention are desirable. This work, together with the development of special graphites, will constitute one of the major research and development programmes of the Dragon Project.

DESIGN PROBLEMS

During the period of early design study, many schemes have been considered and many layout variations have been examined, but the fundamental concept has centred around the use of conventional or well tried engineering design and known structural materials. As far as possible this design aim continues, although of course where a new development shows promise, a keen interest in its possibilities is maintained even if immediate application is deferred; the building of a reactor experiment, however, gives opportunity for subsequent inclusion.

Since the temperatures of the gas coolant are high in the reactor circuit (350°C inlet and 750°C outlet) the aim has been to arrange the design so that running components of any complexity work with low loadings in positions of low neutron flux and at a relatively low temperature. This in turn simplifies the remaining problems of compatibility or the operational limitations of environment. For example, in sufficiently cool positions, grease-packed or oil-lubricated bearings can be considered if oil vapour is reduced to negligible proportions. One of the problems of using a non-oxidizing gas, of the extreme purity needed in the reactor, is that sliding or rolling surfaces do not get the same protection that normally obtains and severe wear or point welding is conceivable under certain conditions. Whilst the use of lubrication in cool areas is expected to give good service, dry rubbing components or the use of electrical components with brushes or sliding contacts must be avoided. For example, it is well known that severe brush wear can occur in aircraft flying at high altitudes. Furthermore, switch contacts and plug-in electrical joints will require rigorous proof testing with likely ranges of materials.

In this reactor it may be thought that fuel loading, with the gas outlet at 750°C, will present a very difficult problem. True, the charge machine engineering is quite exacting, but with this class of reactor on-load fuel changing is unnecessary. The fuel element life is such that charging can be phased to suit maintenance shutdown, say once per year in a typical base load power plant. Thus the charge machine will not require designing for very high temperatures or very frequent operation. The problems of standing may be more important than wear and tear.

High leak standards

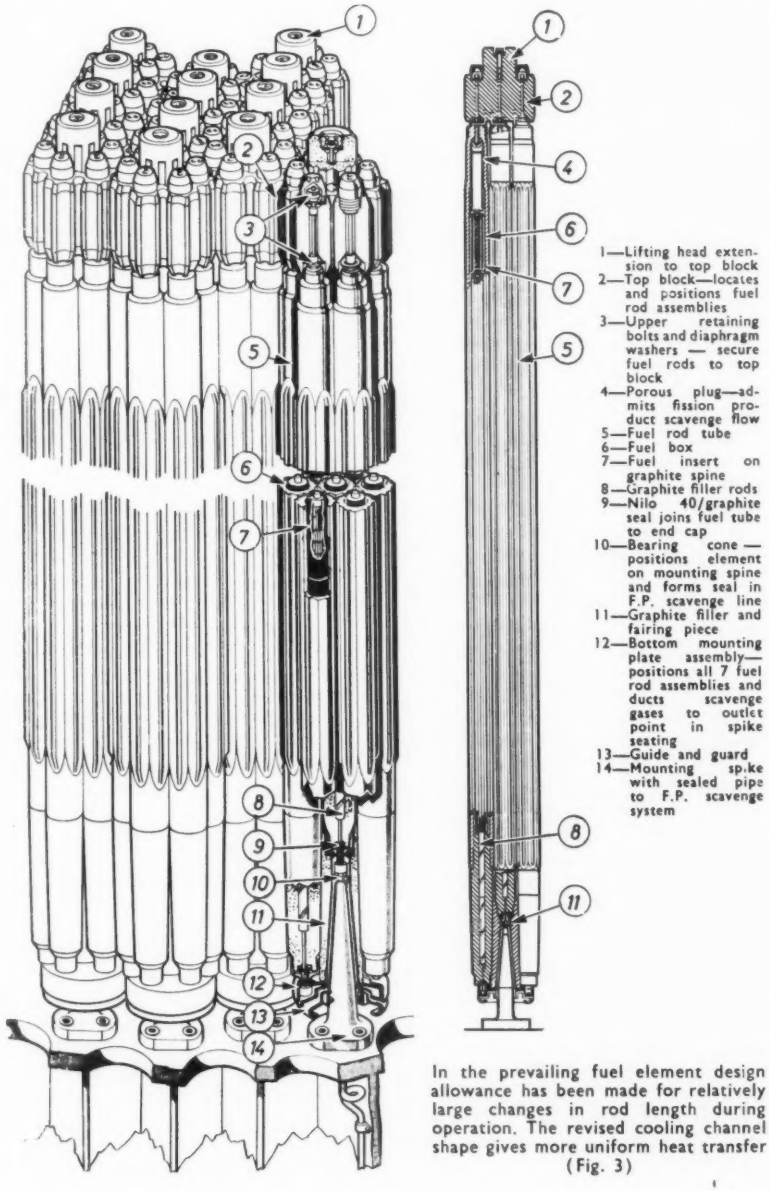
The primary circuit, as indicated already, will contain sufficient fission product contamination to demand high standards of leak tightness. The estimated activity has been reduced to reasonably low working values as a result of proposed improvements in the fuel element and fission product trapping system, but to allow for some loss of retention in the traps under rare but possible circumstances, the leak standards have not been relaxed. To achieve the required containment, all working parts are fully enclosed, either by building the parts into the system or in some cases by capping an enclosure to permit occasional access to such items as a valve stem or a hand drive for maintenance use.

Among the running items which are enclosed in the primary circuit are gas circulators running on gas-lubricated bearings, control mechanisms and a number of motorized drives at various parts of the system. A number of ancillary items also demand appropriate enclosure or sealing, such as viewing and handling equipment to assist charge and discharge. Magnetic

valves, compressors, vacuum pumps and other circuit components such as temperature, pressure and flow measuring items must also be sealed or enclosed in an appropriate manner.

For the primary circuit, in the earlier periods of the design study, a single circuit was proposed using one water-cooled heat exchanger to remove reactor heat. The single circuit required no isolating valves but it used two circulators in series to provide safety duplication. The present intentions are to use six parallel but self-contained branch circuits where each carries a heat exchanger and circulator. There are still no isolating valves in each branch but, as before, a by-pass valve is included in each heat exchanger to permit direct control of overall heat-exchanger performance. This is necessary since, for various reactor outputs, coolant flow must be changed in direct proportion to power output and to maintain inlet temperature at the required value the heat-exchanger performance requires adjustment. Coolant pressure remains constant.

The coolant flow will be controlled by varying the circulator speeds of the six circuits in parallel over the required range of power outputs. The circulators will use built-in three-phase induction motors driven by a variable frequency external supply. In this application the circulators and their motor rotors require gas-lubricated bearings. The use of six circuits in parallel not only provides a greater margin of safety against unit failure but it results in smaller sizes of circulator unit, giving a lighter design and a wider achievable speed range under hydrodynamic conditions. Gas jacking to provide hydrostatic conditions will only be provided at start-up.


1—Lifting head extension to top block
2—Top block—locates and positions fuel rod assemblies
3—Upper retaining bolts and diaphragm washers — secure fuel rods to top block
4—Porous plug—admits fission product scavenge flow
5—Fuel rod tube
6—Fuel box
7—Fuel insert on graphite spine
8—Graphite filler rods
9—Nilo 40/graphite seal joins fuel tube to end cap
10—Bearing cone — positions element on mounting spine and forms seal in F.P. scavenge line
11—Graphite filler and fairing piece
12—Bottom mounting plate assembly—positions all 7 fuel rod assemblies and ducts scavenge gases to outlet point in spike seating
13—Guide and guard
14—Mounting spike with sealed pipe to F.P. scavenge system

In the prevailing fuel element design allowance has been made for relatively large changes in rod length during operation. The revised cooling channel shape gives more uniform heat transfer (Fig. 3)

Active coolant circuit

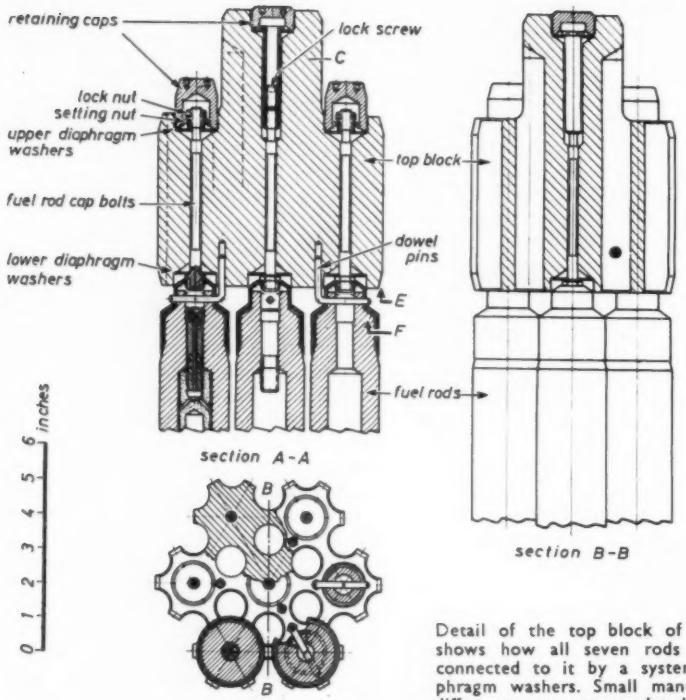
Various studies have been made of the cooling circuit, and in view of the active coolant gas in the primary circuit a great deal of thought has been given to systems with double-wall heat exchanger surfaces to minimize the possibility of active gas leaking into the secondary circuit, the intention being to monitor a common space connecting the inter-surfaces for leakage.

The conclusions reached show that double-wall tube systems introduce many stress complications and manufacturing uncertainties, whilst the use of single-wall tubes produces sounder and more reliable engeering with better opportunities for testing during manufacture and, consequently, less likelihood of subsequent leakage. The use of single-wall heat-exchanger tubes is also more in keeping with the needs of subsequent power producing systems where the maximum heat exchanger efficiency will be sought, and by using this solution, useful information and experience will be obtained in the Reactor Experiment.

The possibility of active gas leaking into the secondary circuit is covered by building the whole secondary circuit within the reactor containment shell. This is a shell within the reactor building surrounding the whole reactor. A shield wall is built around the containment shell so that it may be used as a hot cell for the removal of active components.

The shell itself will contain any active reactor gas which has leaked from pressure vessel or connected equipment. The containment standards of the pressure system limit the quantity of leakage gas, and a system of controlled ventilation maintains a safe equilibrium level within the enclosure.

In studying single-wall heat exchangers, the possibility of water leaking into the reactor has also been considered. This problem is alleviated by the use of multiple parallel circuits where the total quantity of water in each circuit can be kept to acceptably low values. In practice one would expect a small leak to occur long before a serious penetration and since the reactor pressure is higher than the secondary circuit, primary circuit gas



fragmentary section E & F

Detail of the top block of Figure 3 shows how all seven rods are now connected to it by a system of diaphragm washers. Small manufacturing differences are accommodated by elastic deformation of the diaphragms (Fig. 4)

will be detected. Minor quantities of water in the reactor will of course be removed during circulation of coolant gas through the purification unit.

Each of the six secondary cooling circuits consists basically of a closed pressurized loop connecting each primary reactor heat exchanger to a secondary. The system pressure will be somewhat less than reactor pressure and steam will be generated in the secondary side of the reactor heat exchanger and condensed in the secondary heat exchangers. Heat is removed from the latter by tertiary pressurized water loops rejecting heat to atmosphere through blown air-cooled exchangers adjacent to the reactor. Under normal running, the tertiary circuits use circulating pumps whilst the secondaries circulate naturally at all outputs. If power fails and the reactor shuts down, self-induced circulation can carry away shut-down heating in all of the above circuits.

Reactor shell used as hot cell

The use of the reactor containment shell as a hot cell has resulted from a number of considerations, but the small size of the reactor produces an overriding reason for avoiding the use of heavy shielded flasks for the removal of reactor components: the mounting points are too close together to allow a practical design. The philosophy of using permanent built-in shielding with observation windows provides the most convenient solution. Components can be removed without local protection and then transferred to a wheeled transit vehicle. This method has the maximum flexibility, light cranage can be used, and good observation can be maintained.

In the case of the fuel element, or any other item taken out by the charge machine, a gas lock is used to remove them from the reactor pressure circuit. However, before major items such as heat exchangers can be extracted, the system gas will be removed before breaking the seal. The item removed will, where necessary, be placed in an enclosing cannister or sheath before transfer to the shielded transit vehicle. Removal through the building entry locks is then permissible.

Items connected to the reactor pressure system which may require maintenance or replacement have been designed to permit removal by one of the above methods. This includes all the electro-mechanical drives. The principle used is to make the assemblies in the form of self-contained working units of two basic types: firstly, those which contain the minimum friction, for example, control drive mechanisms which release control elements for reactor shut-down, and secondly those where the friction of seals on a high torque driving shaft are unimportant. In the former case each whole unit, with its motor, position transmitter, position switches, gearing and braking arrangements, is completely contained in the pressure enclosure. In the second case, the electro-mechanical items including their gearing can be built outside a bulkhead containing a twin shaft-seal. Normally this assembly would be contained in a pressure enclosure or cover, but for maintenance access the enclosing cover can be removed without breaking the reactor seal. A safe barrier can be provided for maintenance occasions by pressurizing the interspace between the shaft seals with clean helium.

To ease the problem of making low leakage demountable joint flanges, they are arranged to occur at relatively cool positions in branches of the main pressure vessel. By choosing cool positions, the extent of any thermal movement due to relative local expansion will be kept small. A joint which is initially tight is not likely to remain so if movements take any of the component parts beyond the range of elastic recovery. It is also intended to include in each joint flange a second outer seal to form an interspace which can be monitored for leakage. The relatively low temperatures of these joints make the use of an elastomer material for the outer sealing ring a workable proposition.

REACTOR DATA

Performance	
Thermal output	20 MW
Core	
Equivalent dia.	107 cm (3 ft 6 in.)
„ length	160 cm (5 ft 3 in.)
Mean power density	14 MW/m³
Cooling channel voidage	13%
Mean heat flux over fuel element surface	24 W/cm²
Reflector	
Material	graphite
Overall height	244 cm (8 ft)
„ diameter	9 ft 6 in.
Fuel elements	
Material	graphite/ U-235/Th
Cladding	graphite
Length of rod	~ 190 cm (6 ft)
Number in element	7
Length of element	~ 240 cm (8 ft)
Pressure vessel	
Material	steel
Diameter	350 cm (11 ft 6 in.)
Coolant	
Type	helium
Pressure	20 atm.
Inlet temp.	350°C
Mixed mean outlet temp.	750°C
Pumping power	2% full load output

REACTOR LAYOUT

The reactor diagram, Figure 1, indicates the general arrangement and the positioning of many of the components described generally in the previous sections. The pressure vessel shell is held substantially at inlet gas temperature by routing the inlet gas as shown. The hot outlet gas in all cases is separated from the pressure vessel by annular spaces carrying the cool inlet gas, temperature resistant linings being provided in the ducts and in the hot box above the core. All structural members within the reactor are thus positioned to experience inlet gas temperatures. In preliminary designs the inlet and outlet ducts were on opposite sides of the vessel (*1*).

The reflector and the lower temperature end of the fuel elements stand on beds which are in turn suspended from the pressure vessel. Each fuel element rests on a mounting spike which makes connexion to a fission product purging line. The upper ends of each fuel element are held in contact by a ring of reflector columns surrounding the core. A fluid clamping pressure is provided by excess pressure of the inlet coolant acting on the outside.

Control absorbers are situated at the core boundary in vertical holes through the inner reflector columns. In addition further control is achieved by moving graphite in special core elements. It can be seen in the diagram that the core control elements are driven from beneath the reactor while the absorber elements are actuated from above. In both cases the drive mechanisms are housed in pressure enclosures positioned in cool and protected areas, well clear of the reactor in accessible positions for replacement. The actual control elements are in both cases arranged so that removal can be carried out by the fuel element charge machine. As shown in the diagram the charge machine is mounted above a protection shield plug in the neck of the pressure vessel. This shield also carries winding units from which the control absorbers are suspended. After grappling a winding assembly, the charge machine can extract it together with the suspended absorber element. Before removal, however, the driving shaft connexion between the control mechanism and its winding head must be separated by endwise withdrawal. This operation can be carried out without breaking the seal.

Since the suspension cables carrying the absorber elements pass through the hot box carrying the hot outlet gas, they are protected by enclosures of tubular heat barriers. A portion of inlet gas is passed through these tubes to cool the absorbers and to pick up some of the core leakage heat. The tubular heat barriers can be partially lifted after removal of the winding heads and this will allow the charge machine to remove the graphite reflector columns at the core boundary. Should a control absorber become detached by cable breakage, it will rest in a reflector column which can be removed for recovery.

Charge/discharge procedure

The charge machine itself is permanently housed in the upper portion of the reactor pressure vessel. This region is supplied with a small flow of primary circuit gas which has been cooled to a temperature of about 50°C, thus keeping the charge machine at a low temperature. It then flows through the shield plug to remove the induced heating before returning to the reactor.

To remove a fuel element, the reactor must be shut down. The charge machine grapple will then remove filler plugs from a central hole in the shield plug. These items are parked within the machine enclosure and the grapple can be entered to remove a fuel element. To discharge an element from the reactor it is first taken into the chamber above the shield where it is canned before passing out through a gas lock for transfer to storage.

The reactor vessel is mounted inside an assembly of steel and water thermal shields which protects the surrounding concrete biological shielding. They are also load carrying members, and the water cooling carries away shield heat and reactor leakage heat, the leakage heat being reduced by an intermediate thermal barrier. No contact lagging is used on the main shell.

The main proposals for engineering the reactor itself are covered here but a number of alternative solutions exist to many of the proposals described, and subsequent research and development support can revise various points of detail. In addition, design studies continue in a number of directions: for example, the secondary circuit can equally well be satisfied by a pumped evaporative system, or a pumped pressurized hot water system. Both these alternatives can be arranged to circulate naturally for the purpose of removing shut-down heat.

FUTURE POSSIBILITIES

Reactors in this class, using graphite as the moderator with small sizes of core and limited fuel investment, such as the 20 MW Reactor Experiment, will have low conversion factors since criticality requirements limit the amount of fertile material which can be included in the core. However, the limited fuel cycle efficiency does not necessarily produce poor fuel economics, and future applications using small sizes of reactor can well be considered.

With the larger output systems, the fuel economics become very attractive. This, coupled with the small physical size of the plant and lower capital costs, make future applications look very promising on paper. If similar power densities and coolant pressures are used to those in the Reactor Experiment, a reactor for producing an output of 1000 MW heat could be housed in a pressure vessel of little more than 20 ft diameter.

The complexities of an active circuit require an expenditure which cannot be accurately predicted for future use without operating experience. Present knowledge demands that the fission product plant should be overdesigned so that a scaling up of costs for later and larger systems would not be realistic, particularly if better containment is achieved within the fuel element.

In considering the gains which would result from better fission product containment within the fuel element, the achievement of complete containment would mean that no fission product plant would be necessary, although of course a gas purification plant would still be required. With near-complete containment the fission product take-off lines could be omitted and the gas circuit itself could be dealt with by having a fission product trapping system in a by-pass gas purification circuit. Either of these achievements allow greater flexibility of core design. This would be of great benefit for large cores, since it would allow the use of shorter fuel element sections which can be stacked: this in turn reduces the headroom needed for charge-discharge operations. It also makes possible a wider range of fuel rod or cooling channel pitches than those practicable with long rods. A cost reduction could therefore follow in several directions.

In considering the types of power producing plant which can be linked to an HTGC, many interesting design studies will have to be made on both steam and gas turbine systems, before a choice can be made for any given application.

Acknowledgment

The authors wish to acknowledge the part played by all those who have contributed to the work which has made possible the publication of this article.

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1. 'Dragon — details of the 10 MW HTGR' NUCLEAR POWER 1959 *4* (36) April p. 102

1960
LONDON

1st Materials Conference

Papers and new ideas for engineers

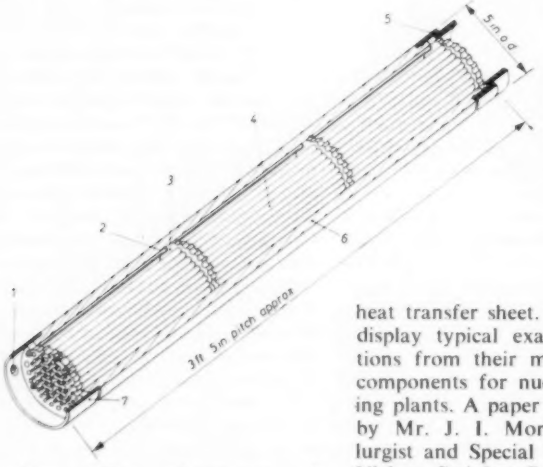
THE FIRST Engineering Materials and Design Conference and Exhibition in the United Kingdom will be held at Earls Court, London, between February 22 and 26. The papers to be presented will cover the development of new components, designs and materials, and new uses for the old ones with special reference to standardization, safety factors and appearance. While the basis of the conference is engineering in general, there will be several papers and exhibits of special interest to those in the field of nuclear engineering.

AEA's work on beryllium

Dr. A. J. Martin who is in charge of the beryllium section at AWRE, Aldermaston, will read a paper 'Beryllium as a Structural Metal,' in which he will consider the physical and mechanical properties of the metal and make comparisons with conventional materials such as iron, aluminium and magnesium. The advantages of strength-to-weight and rigidity-to-weight are set against the disadvantages of cost, toxicity and room temperature brittleness. The Metals Division of AWRE are supporting this paper with an exhibition of current and potential applications of beryllium which will include fuel element cans for the AGR at Windscale together with details of the division's work in developing this metal.

Titanium alloys and steels for high temperature and tensility will be the subject of a paper 'Vacuum melted materials' by Mr. H. C. Childs, research manager of Jessop-Saville Ltd. The metals to be discussed have been developed primarily for gas turbine components, but the possible inclusion of such units in closed-cycle systems for nuclear marine propulsion purposes should not be overlooked. Other exhibitors showing these comparatively new materials will include Imperial Chemical Industries Ltd., the Magnesium Industry Council and Henry Wiggins & Co. Ltd.

The Metals Division of ICI will present aluminium, special copper alloys, titanium, zirconium and a range of the 'new' metals including hafnium, niobium and vanadium with fabricated components in the form of nuclear fuel cans, Integron, Tube-in-Strip and heat transfer sheet. Firth-Vickers will display typical examples of fabrications from their materials, including components for nuclear fuel processing plants. A paper is being presented by Mr. J. I. Morley, Chief Metallurgist and Special Director of Firth-Vickers Stainless Steels Ltd.



AGR FUEL CAN
1 Connector rod pin hole 2 Tie rod 3 Support grid 4 Fuel element rods 5 Top end ring 6 Graphite sleeve 7 Bottom end ring

Welding standardization

For some time the British Welding Research Association have advocated the correct design of welded components and their exhibition will include sets of model structures to help designers make complete and correct specifications of welds which will give the full economic advantage of welding with safety. These models include reinforcing plates on cylinders and branch attachments. Another exhibit of standard welding components will be that of APV-Paramount Ltd. and it will include their range of Paralloy 'Forging Quality' cast stainless steel pipe fittings produced to British and American standards for chemical and nuclear engineering industries.

The subject of standardization is covered by Mr. R. K. Whitehead, Standards Engineer of The English Electric Co. Ltd., in a paper 'Standards in Design.' He will consider the advantages of designing standards into a product, the basis for the formulation of standards and resulting simplification in production. In support of these ideas, the British Standards Institution have recently issued a new publication 'The operation of a company standards department' reviewing the fundamentals involved in introducing standards into a design.

APV STAINLESS STEEL FITTINGS
Each component is fully radiographed, pressure tested and machined for welding as part of its normal production

Metallurgical techniques

Other ferrous and non-ferrous metals will be the subject of a number of papers at this conference and including 'Magnesium Alloys for Engineering Use' by Mr. P. A. Fisher, Chairman of the Technical Panel of the Magnesium Industry Council; 'Powder Metallurgy' by Dr. L. Harrison of Sheepbridge Engineering Ltd.; 'The Design and Application of Investment Castings produced by Centrifugal Methods' by Mr. I. L. Gwynn, Director of P.I. Castings (Altrincham) Ltd.; and 'Cast Iron as an Engineering Material' by Mr. H. Morrough, Director of The British Cast Iron Research Association. Non-metallic materials will also be the subject of papers and exhibits, special reference being given to high temperature conditions. With the inclusion of processing pumps, seals, hydraulics and other detailed items in the subject matter of the conference and exhibition, the benefits to be derived from good designs employing up-to-date materials and standards can be fully appreciated.

1960
LONDON

Physical Society Show

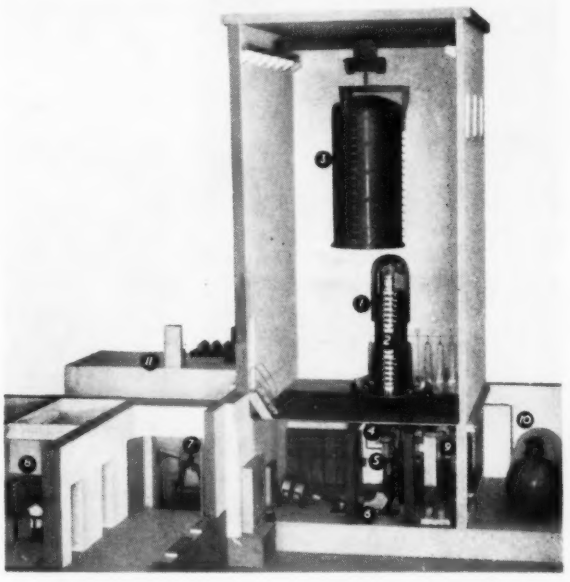
NUCLEAR POWER reviews new equipment of interest to the nuclear technologist

A SIGNIFICANT feature of the 1960 Exhibition of the Physical Society, one which reflected the Government's present policy towards science, was the number of official establishment and Government-sponsored associations that exhibited. While the total number of stands this year was slightly lower than last year, no less than forty-two departments and establishments were represented as against twenty-seven for the 1959 Show.

The United Kingdom Atomic Energy Authority displayed equipment developed by AWRE and AERE's Accelerator, Electronics, CTR and Isotope Divisions at Harwell and the Chemistry Division at Harwell and Woolwich. The Aldermaston exhibits included a multichannel complex programmer for the routine testing of electronic equipment and which could also be used for programming a long chain of chemical processes, using transducers to monitor temperatures, pH factors, etc; a quantitative analysis meter for impurities in inert gases (see '*Industrial equipment for noble gases*', NUCLEAR POWER, January, p 122); and a gravity photo-sedimentometer for particle size determination in the approximate range of 5-70 microns in which the sample is introduced into a settling tank of optically flat glass and is magnetically stirred. Employing a parallel beam of light which is chopped by a synchronously driven mirror, a reference optical wedge and a continuous recorder, the optical density, between the limits of 0 and 0·8, is given directly.

The Woolwich section of AERE's Chemistry Division has developed a prototype monitor for the direct determination of beryllium in the atmosphere. This instrument is capable of continuous operation and will give one determination per minute. The air to be sampled is passed through a triggered a.c. arc and the emitted light dispersed through a grating monochromator after which it is measured by two photomultipliers.

Harwell exhibits ranged from demonstrations of the basic principles of the direct conversion of heat into electricity through data handling and isotopes to a combined purification system for radioactive waste. One of the CTR items was a segmented liner for high-current discharge tubes employing a new method of construction. The surface of the wall is divided into many insulated metal segments, each of less than critical area, which makes it possible to inhibit the formation of 'unipolar' arcs and so reduce contamination of the discharge by material from the wall of the tube.



4 MV ION ACCELERATOR MODEL—Basle University

1 4 MV cascade generator 2 Acceleration tube 3 Pressure tank 4 Deflexion magnet 5 Vacuum diffusion pump 6 Analysing magnet 7 Target room 8 Control room 9 Gas cooler 10 Gas storage tank 11 Machine room

Fission counters which have been developed for long-term operation at 500°C and which have already been used experimentally at temperatures of 700–800°C were shown. They are constructed from stainless steel or nimonic alloys and a high purity alumina ceramic has been used for the lead-through seals, the extension lead and electrode insulators.

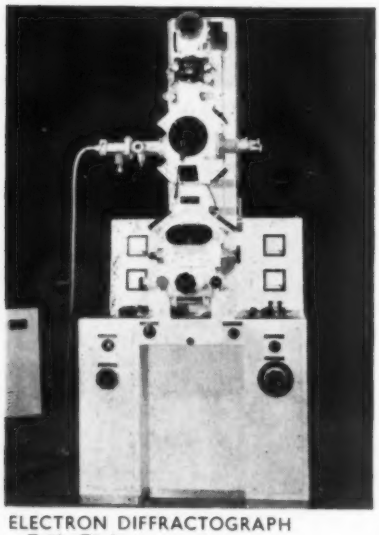
Demonstrations were given by the Isotope Research Division of a radioisotope X-ray spectrometer for the analysis of alloys and for coating thickness measurement together with two instruments for the measurement of gamma ray flux using cadmium sulphide single crystals. In one, the crystal is mounted at the end of a short probe as an integral part of the unit and in the other, the crystal is located at the end of a length of cable which can be inserted into otherwise inaccessible cavities.

Complying with the new regulations

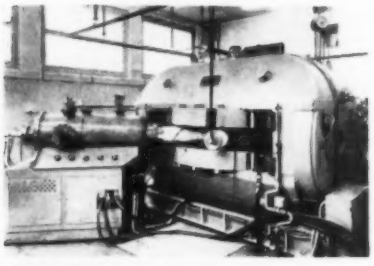
In view of the Radioactive Substances Bill for the control of radioactive waste discharge that has recently been introduced by the Government, the combined purification system evolved by the Chemistry Division is of great interest to all establishments using comparatively small amounts of radioactive contaminated water. It is a continuous three-stage purification process which enables the waste water to be decontaminated and made fit to discharge safely into rivers or reused on site.

The three stages are, firstly, the precipitation and settling of a calcium-

iron-phosphate floc at pH11, this removes 90% of the contaminate. The water is then passed to an electrodeionization cell which removes approximately 99% of the electrolytes of the water, including alkalis and anions, thus reducing the activity to about 0·1% of its original value. The last stage consists of an ion exchanger of either vermiculite or mixed bed organic resins type. Both the combinations of 1 + 3 or 1 + 2 purifies the water to better than drinking water tolerance. The former combination, with vermiculite, has been tested at Harwell on a 500 gal/h scale and the latter is at present being tested in a 50 gal/h pilot plant.

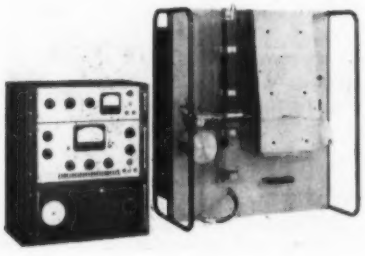


ELECTRON DIFFRACTOGRAPH
—Trüb, Täuber



CYCLOTRON MAGNETS
—Oerlikon

LIQUID WASTE CONTROL
—Landis and Gyr



New materials

While the vast majority of exhibits were of prototype and early production research instruments and equipment, there was a limited amount of new materials displayed that were of interest to the nuclear and associated fields of engineering. Gallium arsenide, the new semiconductor material, was introduced by the Services Electronics Research Laboratory. This has several advantages over the earlier germanium and silicon transistors. A gallium arsenide, GaAs, diode performs well at temperatures up to 300°C as against a maximum of 150°C for the silicon type; and the electron mobility in pure GaAs is over 10,000 and in the case of doped material with an impurity content of 0·01%, the mobility is 1500 compared with 600 for similarly doped germanium. As the lifetimes measured in GaAs so far are extremely short, possible applications have been limited to fast switching diodes and already such items have been made with a transition time approaching two millimicroseconds, so fast that they can be scarcely measured with the present apparatus. Possible future uses are in gaussmeters and strain gauges.

Although still on a prototype basis, Murex have developed the production of electron beam refined rods of tantalum and zirconium to a stage where they have now fabricated chemical plant items that have high resistance to corrosion. Another company, now producing a wide range of pure metals together with alloys based upon them, is Johnson, Matthey & Co. Ltd. In most cases there is more than one grade of purity available and typical metallic impurities are quoted against each grade.

Of possibly more direct application to nuclear installations was the Chance-Pilkington Optical Works solid glass radiation shielding window. The 29¼ in. thick glass block shown provides protection from a cobalt-60 source equivalent to that given by 48 in. of normal concrete or 9½ in. of lead. Various combinations of thicknesses are now available to meet specific applications (see *Progress in Industry*, NUCLEAR POWER, March 1959).

To meet the increasing demand for pure nitrogen, AEI-Birlec Ltd., have introduced a new nitrogen purification plant which reduces the oxygen-containing constituents in the gas to the region of 10 ppm.

Unconventional materials which Accles & Pollock Ltd. have developed and which were exhibited in tubular form included tantalum, niobium, zirconium, molybdenum, vanadium, titanium and titanium alloys. While these metals are expensive, the production of components by tube manipulation techniques eliminates much of the waste inevitable with other methods. A range of flexible yet seamless tubes, developed for nuclear installations, were shown in austenitic stainless steel, Inconel, titanium and non-ferrous alloy forms. Another type of tubing recently introduced has been designed for lightweight pipe-assemblies. This is semi-flexible and can be easily bent *in situ* by hand. Both the flexible and semi-flexible tubing is produced by convoluting plain seamless tube and can be supplied with either helical or annular convolutions.

Swiss exhibits

This year the Council of the Physical Society invited Switzerland to show a selection of instruments. Under the auspices of the Swiss Physical Society and the Swiss Office for the Development of Trade, six companies took part in the exhibition. The main feature was a model of the 4 MV Ion Accelerator built by Emile Haefely & Co. Ltd. for the Institute of Physics of the University of Basle for nuclear research. The accelerating voltage is developed by means of a twenty-stage cascade generator using the Greinacher circuit. With a load current of 1 mA the accelerating voltage shows a load-dependent ripple of ±1 kV by means of an electronic stabilizer governed by an analysing magnet.

Trüb, Täuber & Co. Ltd. of Zürich displayed their KD3 electron diffractograph which was designed as a universal apparatus built up of standard components. Special requirements can be met by the addition of different components which are mainly provided for influencing the object during tests—such as heating up to 900°C or giving low temperature conditions—and diffraction patterns can be observed on a screen or recorded on plates or films.

As in the United Kingdom, attention is being given in Switzerland to the control of radioactive contamination. Landis & Gyr AG have developed continuously operating equipment for the measurement and control of radioactive contamination in a liquid. The measured values from the different counters are continuously recorded on a multi-channel recorder, and an alarm system can be incorporated to operate when a preselected counting level is exceeded.

Magnets for research purposes were exhibited by the Oerlikon Engineering Co. and at present at quadruple magnet, weighing 9 tons, is under construction. Other magnets designed by this company include an 88-ton unit for a propane bubble chamber and a cyclotron water-cooled magnet having

an induction of 16,000 gauss in an air gap of 5½ in. Other Swiss instruments included the Metrohm Potentiograph E.336 and a fully transistorized amplifier fitted with a 35-65 c/s oscillator designed by Ebauches SA.

Scintillation counters

The instruments on Ekco's stand included the universal counter, type N664, which incorporates a high-gain amplifier. It counts beta emitters, including carbon-14 and tritium, in a liquid phosphor, and gamma emitters using thallium-activated sodium iodide crystals. Another Ekco exhibit was a complete set-up for beta counting of liquid samples and comprised the type N530 automatic, general-purpose scaler coupled to a type N575 geiger pre-amplifier and a type N662 round lead castle.

A new precision scanning scintillation spectrometer from Nuclear Enterprises was the Model NE8601, a single channel pulse height analyser which continuously scans and records.

An instrument designed specially for low activity work was the Mervyn large area alpha scintillation counter. It incorporates a 3 in. diameter sample holder and the makers claim that it has over twice the scanned area of any other counter.

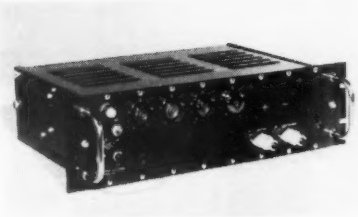
Employing liquid scintillators or thin anthracene crystals, the Panax Equipment Ltd. SC series are primarily intended for low energy beta emitters in liquid or solid form. At present a small refrigerator is under development for the lead castle of this series and at 0°C, efficiencies of 80% for carbon-14 and 30% for tritium have been obtained with backgrounds of 400 and 600 cpm respectively.

Monitoring radiation

The latest EMI portable contamination monitor shown has an all-transistorized circuit which makes it light and compact; and it can be operated from small batteries for long periods.

Isotope Developments Ltd. demonstrated their type 666 Gammalarm. This is a simple wall-mounted unit of a geiger-müller tube and associated electronic circuit which operates an alarm when the radiation intensity exceeds a pre-set value. It has a range of from 0·2 to 2 mr/h and can be arranged to operate interlocks and alarms in a number of different locations.

The Plessey Co. Ltd. displayed an extensive range of various types of radiation monitors developed by Plessey Nucleonics Ltd. These included the Type PNI 1080 which can detect plutonium in quantities around the maximum permissible body burden; the general-purpose PNI 1065 contamination monitor for laboratory



BI-DIRECTIONAL COUNTER
—Ericsson

or factory use; a milk monitor, PNI 1085, specially designed for use by unskilled personnel; water monitors for continuous operation; and a range of nuclear radiation detectors designed for reactor control, including the PNI 1026, which is being incorporated into a number of reactors at present under construction.

Industrial gauging

Many of the nucleonic gauging instruments have been designed for use in production lines. Baldwin Instruments have developed their fast responding Atomat for the high speed control of machines such as metal foil rolling mills. It has a maximum response time of 0·04 seconds.

Burndept Ltd. introduced a transistorized beta-gamma switch, their BN. 131, which can be used for level control, monitoring the contents of cartons, package counting and flow failure alarms. The circuit operates at very low radiation levels and employs thallium-204 or yttrium-90 isotopes. Another new level indicator is the Panax, type TR56L.

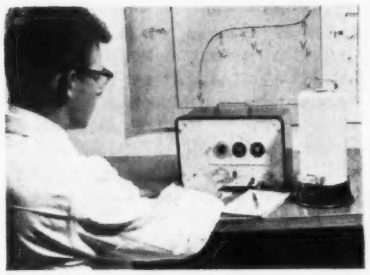
For industrial applications where high inherent reliability is required, Racal have designed the new SA86 transistorized pre-set counter. It is a 4-digit unit but may be used as a 3-digit counter with an early warning signal of up to ten counts.

Equipment for measuring soil density and moisture have been combined into one unit by Dynatron, to assist in the control of soil compaction. Density is measured by a geiger-müller tube and gamma source while a sealed 10 Mc/s radium/beryllium source and a BF_3 proportional counter forms the moisture measuring system.

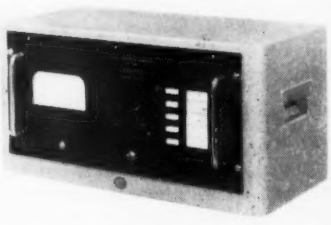
A gamma ray level indicator equipment suitable for remote indication has been developed by Salford Electrical Instruments. Apart from the geiger-müller tube, the detector unit does not contain any valves or transistors and may be located up to 500 yards from the control unit.

Ratemeters and scalers

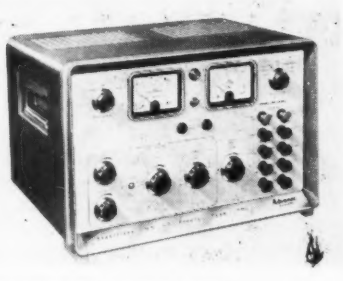
A transistorized ring scaler exhibited by Marshall of Cambridge incorporates a discriminator with a resolving time of 100 ns, followed by



SCINTILLATION COUNTER
—Panax



PULSE SPECTRUM ANALYSER
—Labgear



STABILIZED POWER UNIT
—Advance

one decade scaler having the same resolving time and a second decade with a resolving time of 1 microsecond. An e.h.t. supply provides alternative pre-set output voltages that can be selected by a switch so that different detectors may be used without any other adjustment of the instrument.

A precision ratemeter was demonstrated by Isotope Developments which they claimed is provided with an unusually wide range of time-constants. It incorporates high voltage supply and pulse height selector which enables it to be used directly with a geiger-müller tube or scintillation counter. Also shown was the 1800 series of counting equipment consisting of a range of separate instruments for nucleonic counting and which were designed to permit low cost production.

The Mark II version of Burndept's BN110 ratemeter was exhibited and in this modified form incorporates a facility for increasing the internal cir-

cuit time-constant and it may be converted to operate from a 50 volt a.c. supply. A new ratemeter, the NE5401, has been introduced by Nuclear Enterprises and is now used in their automatic spectrum scanner, NE8601. Its ranges are 30 ; 100 ; 300 ; 1000 ; 3000 ; and 10,000 counts per second ; has an overall stability of better than ± 1% ; and an indicated accuracy of ± 1% of the full-scale reading.

Among the Sunvic products, of the newly formed Instrumentation Division of AEI, demonstrated were prototypes of a unitized system. This has been developed for reactor flux measurement and control, radiation monitoring and fission product detection. The pulse counting and d.c. measuring channels were displayed.

Test equipment

All types of laboratory and field testing equipment were on show. Marshall of Cambridge exhibited an automatic uranium assaying instrument which determines the uranium content of ore samples in a period of less than 25 seconds. Another instrument for use in connexion with uranium processing was the Baird & Tatlock Analmatic pre-treatment unit.

For measuring very small d.c. in high impedance circuits, Isotope Developments have produced the Vibreed 1880.

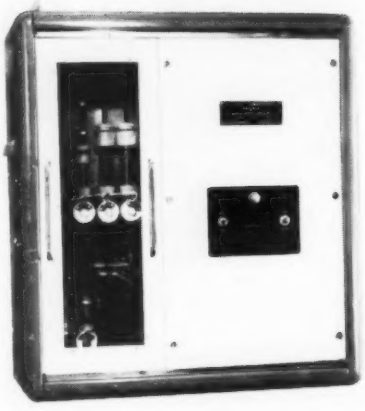
The Cambridge Instrument Co. exhibited their scanning electron-probe X-ray microanalyser which provides a qualitative and quantitative metallurgical analysis by irradiating a minute area of the surface of a sample (see '*Developing advanced materials*' NUCLEAR POWER, November 1959, pp 121 and 122).

Special monocular periscopes for the examination of reactor pressure vessels interiors, normally under 'shutdown' conditions but in emergency under full load conditions as well, have been developed by Barr & Stroud. A model of the design for Berkeley power station was exhibited.

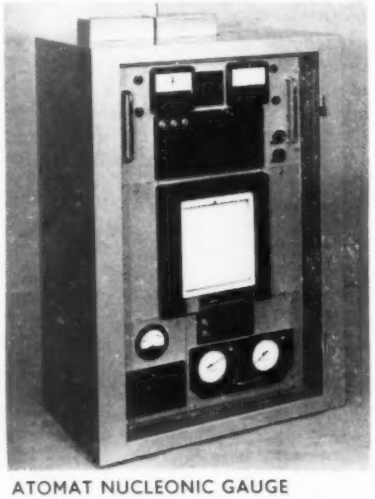
Vacuum techniques

At this year's exhibition particular emphasis was given to techniques involving ultra high vacuums. Edwards High Vacuum Ltd. exhibited their Speedivac pumping group which incorporates a 2M3B mercury diffusion pump surmounted by a water-cooled baffle and two liquid air traps. This installation is capable of producing pressures lower than 5×10^{-10} torr. An alternative system by the same makers was a getter-ion pump with a titanium evaporation source.

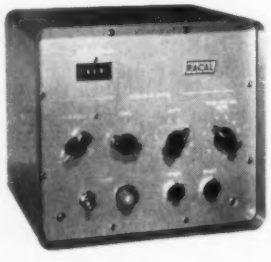
Two other getter-ion pumps at present being developed were shown by Mullard Ltd. and, depending on the efficiency of the pre-processing, final pressures of less than 10^{-10}torr can be attained.



PRE-TREATMENT UNIT
—Baird and Tatlock



ATOMAT NUCLEONIC GAUGE
—Baldwin



PRE-SET COUNTER
—Racal

Practical applications

The uses of modern nucleonic and electronic equipment are greatly increased by the original work carried out by the various Government and Trade Associations. These establishments also do a lot of work in developing standard items and initiating new designs. The Medical Research Council exhibited a scintillation counter that has been designed to measure radioactivity of organic vapours derived from a gas-liquid chromatographic instrument in parallel with the normal analytical chromatographic recording. The vapours are passed into a circulating liquid phosphor and scintillation measured by a photomultiplier tube. Another MRC item, a portable high-pressure ionization chamber for measuring back-ground radiation, has already been used to carry out surveys in a number of Scottish cities. It has long-term stability and a rate-of-drift check of three or four minutes ; it will record a gamma-ray dose-rate of the order of 10 micro-rad per hour with an error of ± 1·5%.

Employing a standard Ekco thickness gauge and an ionization chamber, the British Hat & Allied Feltmakers Research Association have developed a technique to control the build and stretch of hats and hat bodies to prevent the felt becoming thin or broken. The errors in measurement by this method are less than ± 2%.

The University of Edinburgh and the South Eastern Regional Hospital Board, Scotland, exhibited a small free-air chamber for the direct measurement of X-rays, up to about 50 kV, in röntgens. Air absorption corrections are kept as low as possible by the small dimensions of the chamber, 6 cm dia. × 4 cm high. Another technique from the same group, was the use of plastic phosphor vessels for the direct scintillation counting of soft beta-emitters in liquid form. With no sample preparation, carbon-14 and sulphur-35 in aqueous or alcohol solution can be counted with an accuracy of better than 10%.

The National Research Development Corporation demonstrated a new method of analogue multiplication in which the equation $xy = \frac{1}{4}[(x + y)^2 - (x - y)^2]$ was realized in a simple way and the product xy was obtained as voltage from a piezo-electric crystal.

A wide range of comparatively simple instruments were displayed by the National Engineering Laboratory, the Ministry of Aviation, Ministry of Power and the National Coal Board, several of which were intended to measure or control the flow of liquids and solids in an economical manner for industrial applications. It would appear that in this respect a potential exists for the instrument industry to extend their design and development facilities. The efforts of the research establishments could then be directed to a greater extent to their basic function—research.

This series now turns to modern nuclear spectrum analysis, which can involve anything from a modest few channels to the vast number required for elaborate physics experiments. Wherever possible present designs use transistors and ferrite cores for reliability and magnetic tape recorders for economy

Electronics for radiation detection

4—Multichannel analysers

by F. H. WELLS, M.Sc.(Eng.), A.M.I.E.E.
Electronics Division, A.E.R.E., Harwell

1. Introduction

The previous articles in this series have shown how voltage pulses are derived from nuclear detectors and how the peak amplitude and time of occurrence gives information on the energy and velocity of the incident particles or radiation. Thus in a nuclear physics experiment precise measurements of amplitude and time are needed on each nuclear event of interest. Single channel pulse amplitude analysers and coincidence units may be used if nuclear events having only a narrow energy range are to be studied. However, in most cases, a wide range of energy levels are of interest so that instruments equivalent to large assemblies of such single channel analysers are needed, viz., multichannel analysers. The electronic problem then resolves itself into three sections:

a. Sorting the pulses into a large number of different categories or 'channels' in terms of peak amplitude or else time of arrival.
b. Counting or 'scaling' the number of events occurring in each of these categories during the experiment.
c. Recording the numbers given by this scaling operation, these numbers being the results of the experiment.

2. Accuracy requirements of pulse sorting circuits

The paramount considerations are that the mean width of each channel shall be stable and the widths of all channels identical. Figure 1 shows a typical amplitude spectrum which demonstrates the need for good amplitude stability of the order of $\pm\frac{1}{2}\%$ in the amplifiers and sorting circuits. Again, if the spectrum is a smooth level curve and some of the channel widths are greater than the others, then artificial peaks and troughs will be introduced which can be very misleading. This effect must be kept less than the statistical fluctuations of the experimental results, so all channel widths should preferably be uniform to within $\pm\frac{1}{2}\%$ of each other. A small gradual change of channel width from one end to the other of the amplitude spectrum can sometimes be

OUTLINE

After stating the electronic problem of studying nuclear events with a wide range of energy levels and discussing the accuracy required in pulse sorting circuits, Mr. Wells considers the design principles of instruments for pulse amplitude recording. These include multichannel amplitude discriminators, and recorders using pulse amplitude to digital sorting circuits such as the Hutchinson-Scarrott 100 channel analyser and Wilkinson type analysers. He goes on to discuss the more complex instruments for pulse time recording and their use in measuring neutron energy by time-of-flight methods. Finally he describes the use of magnetic tape in multispectrum recorders, and the applications of time-to-amplitude converters to measurement of high neutron energies

tolerated and a suitable correction applied to the experimental results, but there must not be any erratic changes in channel widths.

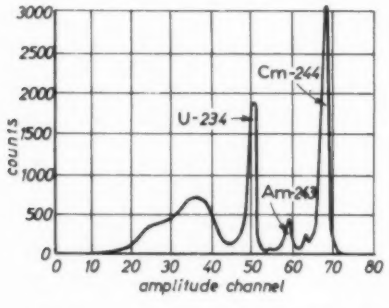
In addition to the stability requirements, care must be taken to ensure that there is negligible chance of two pulses overlapping to give an artificially large pulse; the average rate of arrival of pulses in the experiment must be kept low enough so that this condition is met. Also, the pulses must be of sufficient duration and the base from which they rise must stay close to some defined level in order to allow the electronic circuits to take an accurate measurement of amplitude; the best pulse shape to meet both requirements is produced by the double delay line pulse shaper described in the first article of this series (*September*, p. 95).

3. Pulse amplitude recorders

3.1. Multichannel amplitude discriminators

The pulse amplitude sorting arrangement in this class of amplitude recorder consists of separate amplitude discriminators individually set to define the boundaries between adjacent amplitude channels. The outputs of these circuits are then used to operate separate scalers, one for each amplitude channel, such that each scaler reading represents the number of input pulses whose amplitude fell in the corresponding amplitude channel (*1*). For example, if the amplitude discriminators are set at 5, 6, 7, 8 volts and so on, in 1 volt intervals, then input pulses whose peak amplitudes lie between 6 and 7 volts will trigger the two lowest discriminators (5 and 6 volts) but none of the higher level circuits. The sorting circuit will sense this condition and give a single pulse drive to the scaler registering the 6 to 7 volt channel. Likewise pulses between 7 and 8 volts amplitude will be recorded on the scaler registering channel 7 to 8 volts, and so on.

In this example 1 volt channel widths have been quoted and it has been inferred that the discriminator circuits are set



Typical amplitude spectrum from an ion chamber with a mixed source of alpha emitters illustrates the need for good amplitude stability in amplifiers and sorting circuits (Fig. 1)

at these levels. In a practical circuit the pulses will be amplified by a stabilized gain d.c. amplifier before being applied to the discriminators so that the triggering levels of these latter circuits may be set much further apart in voltage, in order to improve the stability of channel widths. Considerable circuit complication is also needed to arrange suitable automatic ' back-bias ' at the amplifier input to avoid overloading the amplifier; e.g., in the case of a 36 volt input pulse the circuit may automatically bias the amplifier by 30 volts leaving a 6 volt pulse to be amplified giving an output of perhaps 60 volts to the subsequent amplitude discriminator circuits. The correct operation of all these circuits usually takes several microseconds so that the input pulse must first be shaped into a rectangular pulse of the same peak amplitude before being used in the sorting circuits; this shaping circuit takes the form of a diode charging a capacitor.

The disadvantage of this method is that the channel widths, each of which depends on the difference between the thresholds of two discriminators, cannot be kept sufficiently uniform without constant resetting of the amplitude discriminator levels; this method has now become obsolete except in some special cases because of this fundamental circuit defect. In addition, it becomes uneconomical where channel numbers exceed about 30. One advantage, however, is that the circuits can be designed to have quite short paralysis times after each pulse input so that this technique is still used for some applications demanding very high speed amplitude analysis (*2*).

3.2. Amplitude recorders using pulse amplitude to digital sorting circuits

The previous section has shown the difficulties that can occur in obtaining equality of channel widths. However, these errors are not inherent and should not occur in a system where the pulse amplitude is compared with a voltage derived from the addition of a number of equal voltage steps. The number of steps is increased, starting from zero, until the resultant voltage exceeds the input pulse amplitude by not more than one step. The total number of steps is then a ' quantized ' measure of the pulse amplitude and this number may then be sorted to operate channel scalers, using suitable pulse digital techniques, with no further loss in accuracy. Equality of channel widths then demands that all the voltage steps in the comparison waveform should be identical. Two possible circuit methods have been employed:

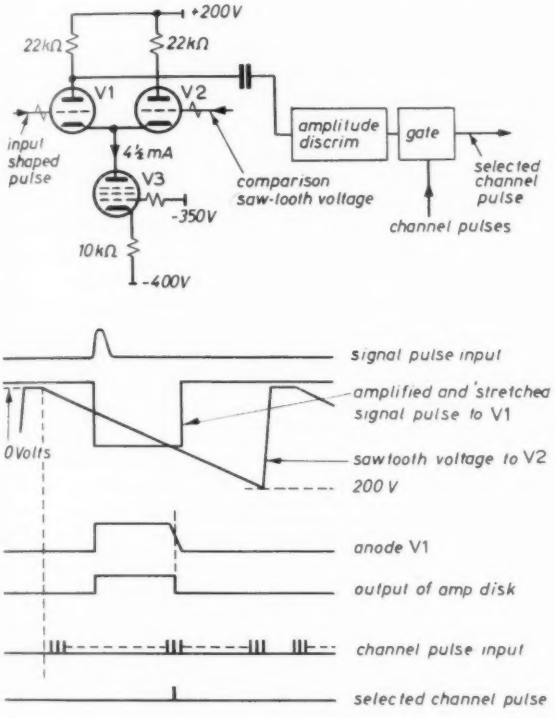
a. An amplitude to time conversion circuit is used and this time duration is then subdivided into equal intervals by a pulsed oscillator technique. The amplitude to time conversion usually takes the form of a linear sawtooth type of circuit so that subdividing the time axis into equal increments has given the effect of subdividing the amplitude into equal increments.

b. Equal increments of charge are added in turn to a storage capacitor by using a diode pump type circuit. The time between the addition of charge increments is controlled by a pulsed oscillator but this time scale is not significant and does not affect the amplitude calibration.

In both these cases it is usually necessary to analyse only a portion of the total available amplitude range; e.g., if the channel width is 0·1 volt there are about 400 channels in a range up to 40 volts of which only 100 channels in the range 30 to 40 volts may be of interest and need to be analysed. Thus provision must be made for accurate selection of the lower limit of range. If the technique of (a) above is used then this selection is obtained by back-bias on the signal input amplifier; the input pulse must exceed a given bias level before being amplified and accepted by the amplitude to time conversion circuit. In the case of method (b) bias on the input signal is not used but instead a charge is added through the diode pump circuit corresponding to the number of channels appropriate to the lower limit of the amplitude range selection; e.g., 300 channels in the example quoted above.

The application of these basic techniques to two practical designs of 100 channel pulse amplitude recorders will now be considered.

Hutchinson-Scarrott Circuit (3). The input pulses are first amplified in a biased amplifier whose gain and bias are set so that the portions of the input pulses which exceed the bias level give rise to negative output pulses up to 200 volts amplitude. This 200 volt range will subsequently be divided into 100 two volt channels. The peak amplitude of an output pulse is stored on a capacitor and compared with the amplitude of a linear 200 volt sawtooth voltage derived from a 'Miller' type circuit. When equality of voltages occurs a gate is opened,



Voltage comparison circuit of the Hutchinson-Scarrott kick-sorter and associated waveforms. This circuit gives identical voltage steps in the comparison waveform by a pulsed oscillator technique (Fig. 2)

which accepts the next pulse from a 'channel oscillator'. This latter circuit is a pulsed oscillator set to subdivide the linear run-down duration into exactly 100 equal time intervals so that this comparison method has selected one out of 100 time intervals; this corresponds to the input pulse peak amplitude. Figure 2 shows the comparison circuit and associated waveforms so that this sorting arrangement has used the technique described in (a) above.

The scaling and recording functions are performed in conjunction with a nickel magnetostrictive delay line acting as a regenerative digital memory. The line has a delay of about 1700 μs with such a low dispersion that a pulse of about 0·5 μs duration may be transmitted, received at the far end, reshaped and then retransmitted indefinitely. In the actual instrument a serial arrangement of 100 blocks of 14 pulses are transmitted, each block representing a 14 stage binary scaler. The presence of a pulse represents a '1' and the absence a '0'. This memory arrangement is used to trigger the linear sawtooth amplitude comparator described above. It is arranged that the comparator output pulse appropriate to a certain input pulse amplitude occurs at exactly the time the appropriate block of 14 pulses is passing from receiver to transmitter of the delay line. The pattern of this block is then changed to add one to the binary code representing the number of events already counted in this channel. The exact details are too complicated to describe in this article, but at the end of the experiment the pattern of pulses in the delay line represents the state of each of 100 binary scalers and is usually displayed on a cathode ray tube or taken out on to a punched card machine; Figure 3 shows a typical display. The average dead time after each input pulse is about 850 μs being half the delay of the nickel line. Some recent instruments of this design have used quartz delay blocks instead of nickel lines to allow the use of pulse durations as short as about 0·1 μs; a typical design uses 1200 μs delay and stores 2000 binary digits (*4*).

The major weakness of this design lies in the use of a regenerative memory system since any electrical disturbance may alter the pattern of pulses and thus destroy the results of a long experiment. It is a wise precaution in such cases to photograph the cathode ray tube at hourly intervals to avoid the chance of complete loss of data. In view of this trouble, the system described next has been found to be more reliable and is probably the best system for both amplitude and time recording.

Wilkinson-type Analysers. The basis of this method is to produce a train of pulses whose number is proportional to input pulse peak amplitude, thus effectively quantizing the amplitude information. These pulses are then counted by a scaler and the resultant state of this scaler is used to select one out of a group of addresses; one event is then added to the number already recorded in this selected address. One address is used for each amplitude channel and there are usually 100 such channels. Figures 4, 5 and 6 illustrate a typical arrangement following the sorting technique described in (a) above, and is similar to the methods originally used by Wilkinson (*5*).

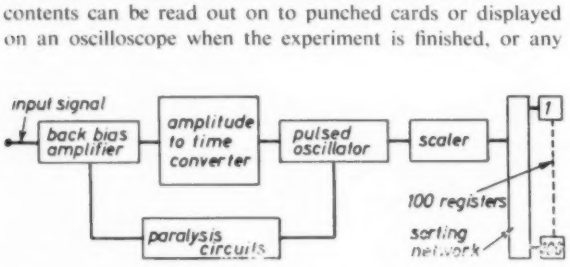
The amplitude to pulse train section must be as accurate as possible so that considerable care must be taken with its design. One recent design by Kandiah and Deighton has resulted in the method outlined in (b) of this section (*6*): the input pulse charges a capacitor to the peak amplitude through an amplifier system stabilized by negative feedback;

Hutchinson-Scarrott analyser display of Cs-137 on a NaI scintillation counter (Fig. 3)

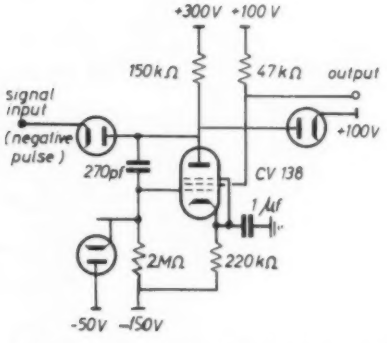
after the peak of the pulse has passed, the capacitor is discharged in small equal steps at a rate determined by a pulsed oscillator until the capacitor voltage passes through its original starting potential; the capacitor discharge is then stopped and the number of pulses from the oscillator during this action represents the pulse train. Stabilities of the order of a few mV equivalent pulse amplitude have been achieved with this method.

After this pulse train 'sorting' circuit the requirement is to store the number of events in each amplitude channel

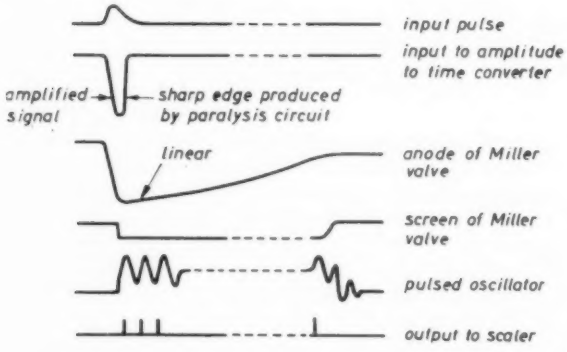
and this was originally performed by Wilkinson using mechanical registers. However, most experiments require a faster storage medium and recent designs (7) use the digital computer technique of a ferrite core store. This store is based on the use of a very small ferrite toroid with an approximately square B-H loop so that it can be left permanently magnetized in one of two saturation conditions. This is used to represent an '0' or a '1' and the magnetic state can be easily reversed in about 2 μs by passing a current of about 0·8 amp through a 1 turn winding. A typical store would then consist of 16 such cores per amplitude channel with perhaps 100 channels. The circuits are then designed such that each group of 16 cores represents a 16 stage binary scaler thus giving storage capacity of about 64,000 events in each of the 100 channels. With this technique an economical assembly of scalers can be constructed since a large portion of the active circuits can be common to all channels. The cores form a store whose contents can be read out on to punched cards or displayed on an oscilloscope when the experiment is finished, or any other time at the discretion of the operator. The display or read-out need not destroy the contents of the store so that the operator can use the display to note what data is being received.



Circuit of Wilkinson 100 channel pulse amplitude analyser (Fig. 4)



Amplitude to time conversion circuit on the Wilkinson method (Fig. 5)



Waveform diagram of Wilkinson 'kicksorter' (Fig. 6)

The total dead time of the instrument after each event consists of the duration of the pulse train, perhaps 200 μs, plus the time to register the event in the storage system, which might be 100 millisecs for the mechanical register or less than 20 μs for the ferrite core storage.

4. Pulse time recorders

These instruments are used in the measurement of neutron energy by 'time-of-flight' methods. Figure 7 shows a typical arrangement where a burst of neutrons covering an energy range of perhaps 1 to 100 eV is obtained from a nuclear reactor through a high speed mechanical shutter; the time at which neutrons pass through the shutter is then closely defined. The 'time-of-flight' of individual neutrons is recorded by opening an electronic gate at the starting time and closing the gate when the neutron actuates the neutron arrival counter. This gate allows timing pulses from a crystal oscillator to pass during its open time so that the time of flight is expressed as a number of timing pulses; these can then be recorded on the same storage medium as used in the Wilkinson pulse amplitude analyser. Thus the neutrons will be sorted into a large number of time of flight channels and their velocities, and hence energies, may be calculated. The figure shows a case where only one neutron can be measured for each shutter opening; this is sometimes sufficient but more neutrons can be measured by a more complex electronic gating arrangement.

If the neutron flight path is very long, then the energy may be measured to great accuracy by this technique and up to 4000 'time-of-flight' channels may be needed; in contrast the pulse amplitude analyser rarely needs more than 200 amplitude channels because of the inaccuracies involved in the energy to pulse amplitude conversion process. Thus, pulse time recorders have been built with ferrite core storage up to about 1000 channels (8); a much larger number of channels is a design possibility but is rather uneconomic in view of the development of magnetic tape recording described below.

5. Multispectrum recorders using magnetic tape

So far we have considered the energy analysis of a series of discrete nuclear particles but in some experiments one or two other parameters may have to be recorded for each particle. One such case occurs in neutron scattering measurements where scattering angles as well as neutron energy must be recorded. Again, two particles or quanta may be correlated and so two sets of related 100 channel amplitude spectra must be recorded, giving 10,000 channels needed in the storage scalers. Thus the ferrite core storage of the Wilkinson analyser becomes too large and expensive for this class of work.

The problem has been solved, following Cavanagh's work (9), by the introduction of magnetic tape recorders to store in digital form the data relating to each individual particle, such as the number of pulses in the train of pulses from an amplitude or time of flight converter. One such system records the data relating to each event as a binary code in a single row across the width of a 16 track 1 in. tape, while another uses a combination of many rows of a 4 track ¼ in. tape system. The recording equipment in use during the experiment can

be kept to a minimum, consisting of the pulse amplitude or 'time-of-flight' to pulse train encoders, auxiliary information coding, and the magnetic tape recording drive circuits.

After the experiment the reel of tape is a permanent record of the data and this is analysed by running it very fast through a separate reading tape transport equipped with a 1000 channel ferrite core store. This instrument is set to select any 1000 adjacent channels and the information is read from the tape into the store giving the total number of events which occurred in each of these channels during the experiment. The accumulated information is then taken out on to punched cards and the magnetic tape is run through again selecting a different batch of 1000 channels, and so on, until all the information of interest on the magnetic tape reel has been read off. Figures 8 and 9 illustrate this method for a neutron scattering measurement (*10*). It should be realized that only one analyser is needed for many recorders since the recording process takes place at low tape speeds whilst the analyser runs the tape at about 100 in. s.

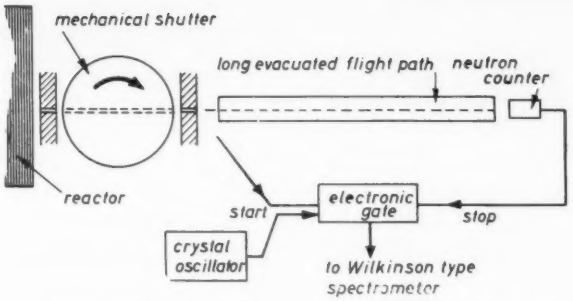
Two interesting design details novel to the application of magnetic tape may be noted:

a. The magnetic tape will introduce errors, or ' drop-outs ', due to faulty recording or reading caused by dust particles or faults in the tape surface. Such errors cannot be tolerated in digital computer practice but for nuclear data recording a fault rate as high as 1 in 2000 digits may be accepted. The electronic design must be such that in the event of a ' drop-out ' occurring the whole data relating to that particular nuclear particle is rejected, so that ' drop-outs ' cause only a small loss of information; the tape recording method chosen facilitates the reject circuit action.

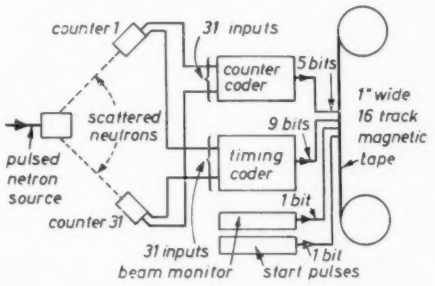
b. To economize in analyser time the information should be closely packed on the tape in order to use a minimum length of tape. However, in most cases the physics data arrives at roughly random time intervals and the tape is running at regular speed so that close packing is impossible. This problem is solved by the introduction of a small ferrite core store in the recorder, which allows data to be temporarily stored or ' queued ' prior to being written on the tape in a more regular sequence.

6. Time to amplitude converter applications

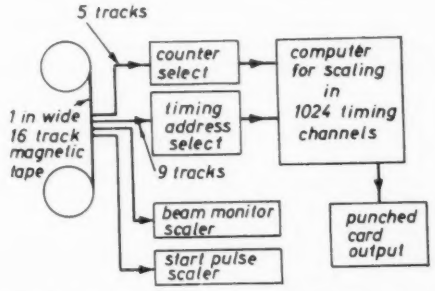
The pulse time recorder technique described in section 4 fails when the time durations involved become too short for conventional scalers and pulse gating circuits to operate satisfactorily. This situation occurs in measurements of high neutron energies by 'time-of-flight' methods; a typical case might involve the sorting of neutrons into 100 timing channels each of 1 nanosecond (10^{-9} secs.) duration. In this case an electronic gate is used as before but instead of giving a pulse train output it allows a defined current to be switched into a suitable capacitor for the gate duration. Thus a change of voltage occurs across the capacitor, proportional to the gate duration or neutron ' time-of-flight '. The capacitor voltage is then returned to its quiescent value before the next event, giving a voltage pulse with peak amplitude proportional to ' time-of-flight '; this voltage pulse is then analysed by a 100 channel pulse amplitude analyser. Each analyser channel then corresponds to a range of ' times-of-flight ' and by altering the storage capacitor values, the channel width may be conveniently varied and may be made as short as 0·5 ns.



Pulse time recorders are used for measurement of neutron energy by time-of-flight methods (Fig. 7)



For recording neutron time of flight on magnetic tape the equipment consists of pulse amplitude or time-of-flight to pulse train encoders, auxiliary information coding, and tape drive circuits (Fig. 8)



The tape is then read and analysed on a separate reading tape transport equipped with a 1000-channel ferrite core store (Fig. 9)

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Reactors

Thermal stresses due to gamma irradiation

by M. J. HILLIER, B.Sc.(Eng.), *Enfield Technical College*

THE ELASTIC thermal stresses in the shell forming a thermal shield or pressure vessel of a nuclear reactor may be an important factor in the mechanical design of small reactors for propulsion. Such thermal stresses are additive to pressure or other mechanical stresses already existing or allowed for. The thermal stresses are induced by virtue of distributed heat sources within the shell thickness, the heat source arising from absorption of external radiation as it passes through the plate. The major sources of thermal stress include:

a. Simple temperature differences across the shell wall;
b. Irradiation by 'thermal' and 'fast' neutrons from the reactor core, moderator or coolant;
c. Irradiation by primary γ-ray photons from the core and secondary γ-rays arising from neutron capture in the coolant, moderator or structure external to the shell considered.

Stresses due to differences in the fluid temperatures at each face of the shell (a) are calculable by standard methods (*5*). The major contribution to the irradiation thermal stress is generally due to the γ-ray photons (c). Neutron capture within the shell (b) and the subsequent emission of γ-ray photons may however be of significance in the total thermal stress. However this effect may be difficult to calculate since the γ-ray produced by thermal neutron capture travels a finite distance before itself being absorbed as heat. A complete analysis of all the heating effects is not to be attempted here. The purpose of this article is to present data allowing a first approximation to the peak tensile stress in an iron plate—given an estimate of the γ-ray energy incident upon one face.

It is assumed that sufficient calculation or experiment has been done on the reactor core physics and shielding to enable an estimate to be made of the γ-ray photon irradiation of the reactor shell, expressed as a current of γ-ray photons/cm²sec. This current is a measure of the total energy falling upon that face. The ability of the iron to absorb the incident γ-rays depends strongly upon their energy, and the γ-ray energies generally of importance in stressing iron plates lie in the approximate range $\frac{1}{2}$ to 8 MeV. For a shell, whose thickness is small compared with its radius, it is usually convenient to consider the distribution of γ-rays within it as within a flat slab. Moreover, if the γ-ray sources are sufficiently far from the shell face (a few mean free paths) the beam of photons may be assumed collimated and monodirectional. In any case this assumption usually gives an upper limit to the heating in the plate as compared with any other geometry or assumed angular distribution of photons. If $J = J(E\gamma)$, (photons/cm²sec) is the incident γ-ray current then the distribution of γ-ray flux within the plate for a collimated beam is approximated by

$$\phi = J \exp(-\mu x) \quad (\text{photons/cm}^2\text{sec}) \qquad (1)$$

where x (cm) is the distance from the front face of the plate, and $\mu = \mu(E\gamma)$ (cm⁻¹) is an energy dependent total absorption cross section (absorption coefficient) for the γ-ray photons. However, not all the neutron-matter interaction described by the cross section μ represents complete absorption, but includes γ-ray photon scattering. An empirical allowance for the build up of scattered photons in the iron, which after a scattering collision with an iron atom continue with a reduced energy, may be made by modifying the total cross section μ by suitable empirical build up factors. Goldstein and Wilkins (*2*) have shown that a suitable expression for the γ-ray flux may be written

$$\phi = J\{A_1 \exp[-\mu(1+a_1)x] + (1-A_1)\exp[-\mu(1+a_2)x]\} \qquad (2)$$

where A_1, a_1, a_2 are empirical factors. In what follows the expression, given by equation (1) will be considered, a corresponding modification to allow for build up of scattered photons using equation (2) will usually be self evident.

Temperature distribution

The volumetric heat source distribution, corresponding to equation (1), is given by

$$H = \mu_e E\gamma J \exp(-\mu x) \quad (\text{MeV/cm}^3\text{sec}) \qquad (3)$$

where $E\gamma$ is the energy per photon and $\mu_e = \mu_e(E\gamma)$, (cm⁻¹), an energy dependent energy absorption cross section. Given the heat source H, the temperature distribution θ may be obtained by standard methods (*3*). The resulting expression is found to be of the form

$$\theta = \mu_e E\gamma J\, \theta'/k\mu^2 \qquad (4)$$

where k (MeV/cmsec°C) is the thermal conductivity of the plate and $\theta' = \theta(\mu x)$ a dimensionless function. The form of θ' depends on the surface temperature boundary conditions for the plate; commonly applicable conditions are:

a. Zero temperature at the inner face upon which the radiation is falling, and thermally insulated (lagged) at the opposite face;
b. Equal surface temperatures.

One surface temperature is conveniently taken as zero for convenience in calculating the resulting thermal stresses. The equations for θ' for these boundary conditions are given by (*1*) and (*3*).

Thermal stress

The elastic stress in a curved shell of radius large compared with its thickness is approximated very well by that for the flat plate restrained from bending (*5*). These stresses are then given by

$$\sigma_x = 0$$

$$\sigma_z = \sigma_y = \frac{\alpha E}{1-\nu}(\theta_m - \theta) \qquad (5)$$

where E is the modulus of elasticity (lb/in²)
α the coefficient of linear expansion (°C⁻¹)
θ_m the mean temperature in the shell (°C)
ν Poisson's ratio

The stress distribution thus follows that of temperature, with a suitable change of origin and of scale. The peak tensile stress occurs at $\theta = 0$ and is therefore at the inner surface of the lagged plate, case (a), and at both surfaces for case (b). By using equations (4) and (5), and making a suitable modification for the γ-ray scattering using equation (2) the following expression for peak tensile stress is obtained:

$$\sigma_{max} = \sigma_0 \cdot \sigma'$$

where
$$\sigma' = A_1\theta'_{m1}/(1+a_1)^2 + (1-A_1)\theta'_{m2}/(1+a_2)^2 \qquad (6)$$

$$\sigma_0 = \frac{\alpha E \mu_e E \gamma J}{(1-\nu)k\mu^2} \quad (\mathrm{lb/in^2})$$

$$\theta'_{m1} = \theta'_{m1}[\mu T(1+a_1)]$$
$$\theta'_{m2} = \theta'_{m2}[\mu T(1+a_2)]$$

In order to take account of the energy dependence of μ, μ_e, J, A_1, a_1, a_2 the total stress is the integral of such pairs of terms as in equation (6) taken over all significant energies. In practice, however, it is generally sufficient to determine σ_{max} for each of four or five energy groups, each having mean energy $E\gamma$. For example the γ-ray currents may be calculated for the five groups having mean energies 1, 2, 3, 5, and 7 MeV, the stress determined for each group and the total stress taken as the sum of the five components.

Peak tensile stress in an iron plate

Curves have been prepared showing the dependence of the peak thermal stress on mean energy for a γ-ray current of 10^{12} photons/cm²sec. The absorption and energy absorption cross sections were those given by (*4*), and the energy absorption 'build-up' factors were taken from (*2*). An iron plate was assumed and the following mechanical data used:

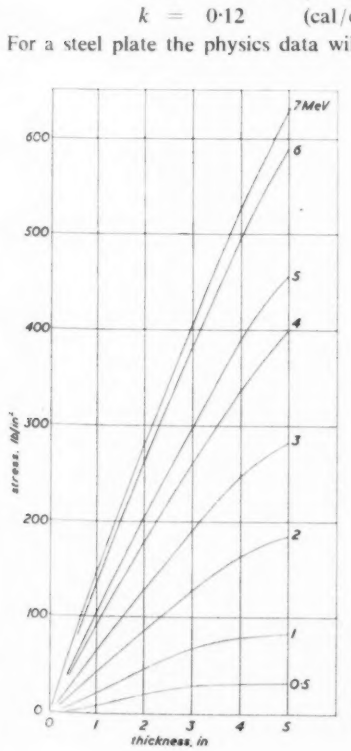
$E = 30 \times 10^6$ (lb/in²)
$\nu = 0{\cdot}3$
$\alpha = 12 \times 10^{-6}$ (°C⁻¹)
$k = 0{\cdot}12$ (cal/cm°Csec)

For a steel plate the physics data will not be far different from that assumed for an iron plate. The stress will depend however upon the factor $\alpha E/(1-\nu)$ and may be obtained by simple proportion.

The following stress values were obtained for the iron plate. Figure 1 plots σ_{max} in the lagged plate against slab thickness in inches for a range of γ-ray energies (MeV). Figure 2 is the corresponding plot for the plate with equal surface temperatures and is seen to give lower stresses than in the case of the lagged plate. It is evident that below about 0·5 MeV the stress due to irradiation can generally be neglected. Moreover, for thin plates and a given incident current of energy the stress is not strongly dependent upon the energy level.

Isotropic γ-ray distribution at one face

The cases considered so far have assumed that the irradiation is a collimated beam of γ-rays at the inner face of the shell or plate. This generally gives an upper limit to the thermal stress. It may be regarded as a conservative assumption and the most reasonable one to take when either the irradiation source is a few mean free paths from the plate; or, if very close to the plate, is a few mean free paths thick (one mean free path $= 1/\mu$). An alternative assumption is to take the irradiation as being isotropically distributed at the slab face. This probably gives a lower limit to the thermal stress and is a reasonable assumption if the source is both very thin in terms of mean free paths and close to the plate. Both the heat source and temperature distribution term θ' differ from those given in equations (1) and (6) for the collimated beam. The heat source is no longer represented by a simple exponential and the temperature function θ' alters correspondingly. The necessary formulae have been given in (*1*) and allow similar calculations of the peak stress to be made as for the collimated beam. Using the same physical and mechanical data as before Figure 3 has been prepared, corresponding to the temperature boundary conditions (b). It is seen that for a given slab thickness and irradiation the stress is lower than in the case of the collimated beam by a factor of about five.



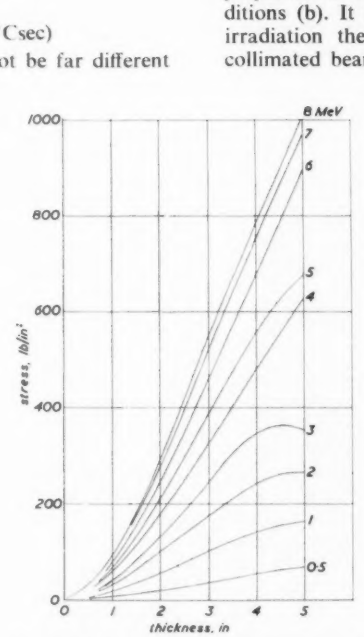


Fig. 1 (left) Peak tensile stress in flat plate restrained from bending: lagged at x = T: γ-ray current 10^{12} photons/cm²sec

Fig. 2 (above) Peak tensile stress in flat plate restrained from bending: equal surface temperatures: γ-ray current 10^{12} photons/cm²sec

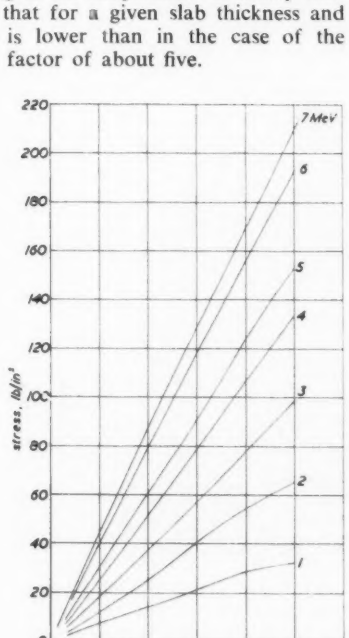


Fig. 3 Peak stress in plate: isotropic γ-ray distribution at x = 0: equal surface temperatures: γ-ray current 10^{12} photons/cm²sec

The stress values given in this article are approximate in the following respects: **a.** No account is taken of radiation effects other than those due to γ-ray photons originating outside the plate; **b.** For the plate cooled by a fluid at both surfaces no account has been taken of the unequal heat flows from the plate to each surface and the corresponding additional temperature gradient; **c.** The cylindrical geometry of thick cylinders has been neglected; **d.** The possibility of gamma irradiation at the lagged surface has not been considered; **e.** Other than the two special cases of a collimated beam and isotropic distribution of irradiation no account has been taken of the angular distribution of irradiation at the face of the slab; and **f.** It has been assumed throughout that the section of the plate considered is that subject to the most intense irradiation and that it is sufficiently far from the ends of the shell or plate to allow this to be treated as an infinite plane slab. However, sufficient information has been given to allow a first approximation to be made to the thermal stresses involved in a given reactor design. Moreover the curves presented give some indication of the stress levels involved at a radiation level of 10^{12} photons/cm^{2}sec.

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Materials

Radiation damage in materials

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SEVERAL THEORIES have already been suggested for radiation growth but various objections can be raised against them. The following theory is suggested as a possible way of overcoming some of these difficulties. In so far as it makes use of stresses round a fission spike it follows an earlier theory due to Wyatt and Pugh (*1*).

The crystal structure of α-uranium is shown in Figure 1. It is based on an orthorhombic cell with axes *a*, *b*, and *c*, of lengths $a_o = 2{\cdot}85$, $b_o = 5{\cdot}87$, and $c_o = 4{\cdot}96$ angströms at room temperature. The atoms are set in corrugated sheets, perpendicular to the *b*-axis, and these sheets are stacked one against another with their corrugations (parallel to the *a*-axis) fitting into one another. The atoms are strongly bonded together within each corrugated sheet by bonds of a rather covalent character, and the sheets themselves are more weakly held together by bonds of a more metallic character. The extreme anisotropy of this crystal structure is shown by the thermal expansion coefficients which are, in units of 10^{-6} per °C, $+ 36{\cdot}7$, $- 9{\cdot}3$, and $+ 34{\cdot}2$, respectively, along the *a*, *b*, and *c*, axes over the range from 25 to 650 C (*2*).

The lattice constants are not significantly altered by radiation and the process of growth involves the actual movement of material from one part of the crystal to another. Its effect is to increase the number of *b*-layers (that is, the corrugated sheets perpendicular to the *b*-axis) in the crystal by a corresponding reduction in the number of *a*-layers (that is, sheets of atoms perpendicular to the *a*-axis). The number of *c*-layers and the thickness of the crystal along the *c*-axis remain unaltered. The rate of growth is quite large, about 10 per cent a year at 200°C in a slow neutron flux of 10^{12}/cm^2 sec. This is equivalent to stripping 1000 atoms off *a*-layers and using them to build more *b*-layers for each neutron fission that takes place.

Consider a small rectangular prism of uranium, for example, 1000 atoms to a side, somewhere inside the crystal. If we suddenly heated this region, for instance by means of a fission spike inside it, to a high temperature we would expect it, from the values of the thermal expansion, to expand along the *a*- and *c*-axes by about 20 atomic spacings and contract along the *b*-axis by about 5 atomic spacings. This hot and distorted region must be strongly constrained by the metal around it that has not yet received the heat of the fission spike, and so there is a strong inducement to counteract the *b*-axis shrinkage by shifting atoms to make more *b*-layers, at the expense of the numbers of atoms which form *a*- and *c*-layers. If such a rearrangement can occur during the heating phase of the fission spike, when the region is very hot, and not occur again

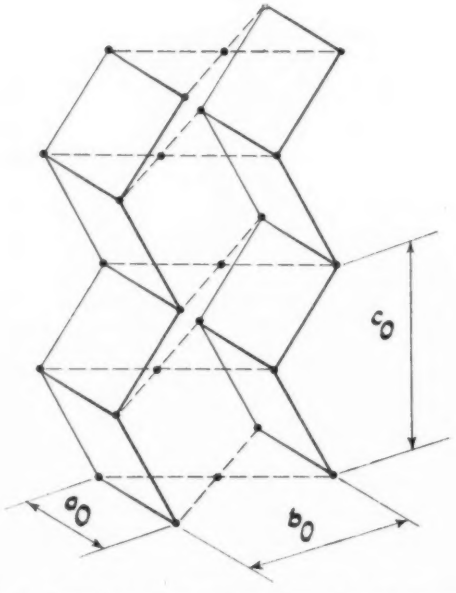

Fig. 1 Crystal structure of α-uranium, showing corrugated layers of atoms. (Not to scale)

in reverse when the region cools down again and the atoms become fixed in their places, then the crystal will expand along the *b*-axis, and shrink along the other axes, by the building up of more *b*-layers.

If the spike occurs in a perfect region of the crystal the process can be expected to reverse itself on cooling be-

cause, as the atoms crystallize again, they will build themselves on to the lattice of the material round the region and so crystallize back into their original arrangement. But spikes that happen to straddle edge dislocations can have a permanent effect because the number of atoms that can be added to, or removed from, the end of the half-plane of such a dislocation is freely adjustable.

One fact about radiation growth immediately explainable by this theory is that the rate of growth is faster in imperfect (cold-worked) crystals than in more perfect ones. The greater the number of dislocations present the more opportunities there are for fission spikes to straddle dislocation lines. The distance between dislocation lines in lightly worked metal crystals is generally of order 1000 atomic spacings. The energy released in a spike is sufficient to melt all atoms in a region about 1000 atomic spacings across, so that many spikes must straddle dislocation lines.

Another fact readily explained is the disappearance of radiation growth at irradiation temperatures above about 450°C. Atomic diffusion is quite fast at such temperatures and there is time for the atoms which were transferred from one dislocation to another, in a spike, to go back to their original places before other spikes are formed in the neighbourhood. It is less clear what happens at low temperatures. According to the theory, growth should occur strongly even at temperatures below 0°C, since the process depends on local temperatures in a spike, which are practically unrelated to the average temperature of the material. Early work on irradiations in a liquid-air cryostat suggested that growth is greatly reduced at such temperatures, but more recent work (*3*) suggests that growth does in fact occur strongly.

Finally, we must consider the absence of growth along the *c*-axis. This may be due to a lack of *c*-dislocations (that is, with Burgers vectors along the *c*-axis), which would be needed for such a growth. The half-planes of such dislocations would have to be 4·96 A ($= c_0$) thick to fit into the lattice, which would make the dislocations have high energies and unlikely to be formed by plastic deformation. By contrast, half-planes perpendicular to the *b*-axis need only be 2·94 A ($= b_0/2$) thick, because perfect dislocations of Burgers vector $a_0/2$, $b_0/2$, 0, can be produced by fitting single sheets of atoms between the *b*-layers. Such dislocations correspond to one of the modes of slip in uranium (*4*). Similarly, half planes of thickness 2·85 A ($= a_0$) can be fitted in between *a*-layers to make *a*-dislocations; such dislocations generate the main slip mode in uranium, which consists simply of the sliding of the corrugated sheets along one another down their corrugations. We may therefore expect *c*-dislocations to be rare compared with those capable of producing growth along the *a*- and *b*-axes.

Acknowledgment :

This article forms part of the 46th Thomas Hawksley Lecture given at a recent meeting of the Instn. Mech. Engrs.

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Processes

Analysis by paper chromatography

by J. R. A. LAKEY, Ph.D., B.Sc., A.Inst.P., *Simon-Carves Ltd.*

WHEN a material under examination is radioactive a filter paper chromatrogram can be developed in the normal way with suitable solvents but the constituents may be identified by detection of their radioactivity, and one method developed for doing this is here described in detail.

The material to be studied is deposited in the corner of a sheet of filter paper, and this is then placed in a tank with its bottom edge in contact with a solvent. The solvent is allowed to pass through the filter paper, after which the paper is removed, turned through 90°, and returned to the tank—possibly in a different solvent. Movement of the solvent across the filter paper carries the unknown material with it and in so doing splits the material into different constituents. These may be identified by comparison with a small quantity of the suspected material. Coloured compounds are easily identified and others may be detected by spraying the chromatogram with a suitable indicator.

When the unknown material is radioactive, the distribution may be identified by an autoradiograph, but a quicker method is to cut the chromatogram into strips which are passed beneath a suitable radiation counter. An additional advantage of this method is that it provides quantitative information on the distribution of radioactivity on the chromatogram, and the amount of detail can be varied by altering the width of the paper strips. Figure 1 shows the apparatus for counting these paper chromatograms.

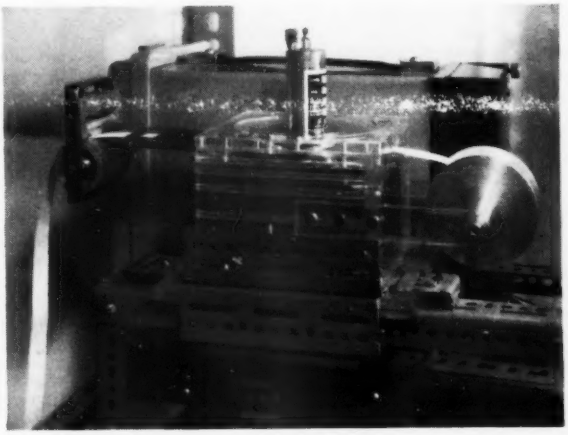


Fig. 1 Counting paper chromatograms

The paper rollers are attached to the mechanism of the pen recorder so that the chromatogram strip is passed underneath the counter at the same speed as the recorder paper passes underneath the pen. The counter is a conventional end-window geiger müller type and the paper is exposed to the full width of the counter through a window 1 cm

long. In the photograph, the recorder is behind the counter and the lead shielding is removed. The counter is operated from a conventional ratemeter unit and the output of the ratemeter is fed to the recorder. The speed at which the strip is drawn underneath the counter can be varied by altering the speed at which the recorder is operated. The apparatus shown has been developed for work with iodine-131 and is used for the study of the distribution of iodine-131 in extracts of thyroid and plasma. However, the method can be applied to almost any other nuclide

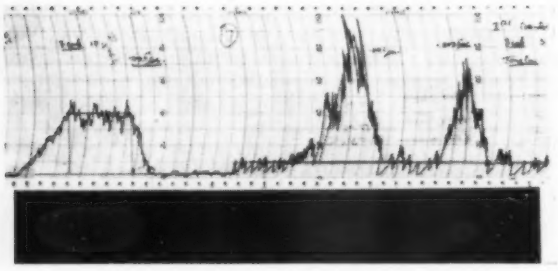


Fig. 2 Typical trace produced by filter paper treated with radioactive iodine

for which radioactivity chromatography is needed. It may be necessary to alter the mode of detection, and it is possible to use a scintillation counter with a suitable phosphor in place of the geiger counter.

A typical trace produced by filter paper treated with radioactive iodine-131 is shown in Figure 2. Below the recorder trace is the autoradiograph of the filter paper. The recorder trace shows the increase in count rate when the spot passes the window of the counter. For the first spot the full-scale reading of the recorder is 10 counts/s and this is reduced to 3 counts/s for the second and third spots. The area traced out by the recorder pen is proportional to the total activity in each spot; this relation is derived in the following paragraphs, with reference to Figure 3.

The filter paper moves at a velocity of v cm/s below an aperture of length a cm. On the filter paper there is a spot of radioactivity of length 1 cm giving the recorder trace shown. This trace records the count rate R in counts/s. The measured area of the radioactive trace is A, which for convenience is expressed in the units of the recorder-paper trace—counts/s multiplied by centimetres.

The total time for which any radioactive spot on the filter paper is exposed to the counter is a/v seconds. The total count produced by this spot is the product of Ea/v and the activity of the spot in microcuries, where E is the efficiency of the counter in counts/s/microcurie. Thus a spot on the chromatogram of activity C microcuries produces a total count of $N = E\frac{a}{v}C$. The total count can be estimated from the recorder trace by integrating $\int_0^T R\,dt$ where T is the exposure time of the spot. However, the variable $t = \frac{x}{v}$, where x is the coordinate of the trace, and so

$$N = \int_0^{1+a} R\,\frac{dx}{v} = \frac{A}{v}$$

Combining these equations we find that:

$$C = \frac{A}{Ea}$$

Since E and a are constants for any one counting system, the area under the trace is directly proportional to the activity of the spot.

The usual value of a, the aperture of the counter, is 1 cm, in which case the activity is simply the area under the recorder trace divided by the efficiency of the counter. The total count produced by the spot is given by the area of the trace divided by the velocity of the paper passing underneath the counter. Thus the accuracy of any one measurement of activity, which depends on the total count, can be estimated directly.

This theory does not allow for the time constant of the recording ratemeter which may be varied by the operator. It can only be said that the time constant must be short compared to the time taken for a point on the paper to traverse the window. It is an advantage to use the maximum time constant consistent with this condition so that a smooth trace can be produced. There is no advantage in using a short time constant since this does not in any way improve the sensitivity of the apparatus.

A practical example will illustrate the use of these equations. Three spots of a calibrated iodine-131 solution were placed on a piece of chromatography paper and after drying were counted under a GM4 end-window counter. The length of the aperture was 1·0 cm and the speed of the chromatography paper and the recorder paper was ½ in./min (0·0212 cm/s). The actual trace and autoradiograph

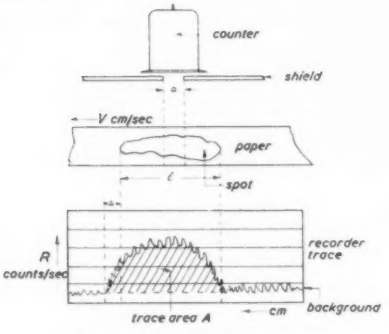


Fig. 3 Strip counting system

of this paper are shown in Figure 2. Table 1 shows the calculation of the efficiency of the counting system from the above theory. The length of the recorder trace is also compared with the length of the spot measured from the autoradiograph. The total count calculated from the area of the trace is given. This table shows that the efficiency of the counter does not vary significantly with the size of the spot, confirming the theoretical result. The effective aperture of the counter, i.e. the difference between the length of spot and trace, is approximately one centimetre.

TABLE 1 *Calibration of paper counter*

SPOT NUMBER	1	2	3
Activity c (microcuries)	0·0005	0·001	0·005
Area of recorder trace A (counts/s/cm)	1·65	3·63	17·6
Efficiency of counter T/Ca (counts/s/microcurie)	$3{\cdot}3 \times 10^3$	$3{\cdot}63 \times 10^3$	$3{\cdot}52 \times 10^3$
Total count T/v	78	171	830
Length of spot (cm)	1·5	2·7	5·2
Length of recorder trace (cm)	2·4	3·5	6·3

Acknowledgments:
The development of this measuring system has been carried out in the laboratories of the G.E.C. Atomic Energy Division, Erith, as part of the combined programme of The General Electric Co. Ltd. and Simon-Carves Ltd.

STUDENTS' NOTEBOOK

GROUNDWORK—Reactors

Why must moderators be used in natural uranium fuelled reactors?

When a neutron strikes an atom of uranium four things can happen: the nucleus of the atom may split up (fission); the neutron can be absorbed by the nucleus and become part of it (capture), forming a new nucleus which is an isotope of the same element as the original nucleus, i.e. has a different physical weight, though retaining the same chemical properties; or the neutron may be simply deflected, either by the ordinary laws of Newtonian mechanics (elastic scattering) or with a total loss of energy in the reaction (inelastic scattering). The chances of any of these events taking place in a given material are indicated by a quantity known as the cross-section of the material for that particular event. A cross-section, which is measured in barns, has the dimensions of area (one barn $\equiv 10^{-24}$ cm^2) and can be regarded as the effective area presented to the neutron for the reaction in question. Its value depends on neutron speed.

Natural uranium contains about 0·7% of the 235 isotope, the remainder being 238. For neutrons of about fission energy (2 MeV) the cross-sections of the two isotopes are comparable, so to begin with we can suppose that the uranium is all 238. The cross-sections are

$\sigma_f = 0{\cdot}29\text{b}$ $\sigma_c = 0{\cdot}04\text{b}$ $\sigma_s = 1{\cdot}5\text{b}$ $\sigma_i = 2{\cdot}47\text{b}$

$\sigma_T = 4{\cdot}3\text{b}$ (total)

and it is easily seen that the chance of inelastic scattering is high (0·57) and the chance of fission low (0·068). Further, if a neutron makes an inelastic collision it is almost certain to be reduced to an energy below that necessary for fission in U-238. However, because of the small capture cross-section only very few neutrons are lost and most of them will simply bounce around, gradually losing their energy. If the neutron energy can be reduced to thermal values (< 10 eV) then the cross-sections are much more favourable, but a further snag is the peculiar variation in cross-section with neutron speed in U-238. At certain speeds the capture cross-section rises to very high values called resonances. Because the neutrons are colliding with heavy atoms the energy loss on collision is small, the number of impacts is large, and a neutron is almost certain to be captured in one of these resonances.

One way out of the difficulty would be to remove all, or nearly all, of the U-238, leaving the uranium highly enriched in the 235 isotope. A chain reaction is then possible using any neutron energy.

Alternatively, one can still use natural uranium, but mixed with another material called a moderator. If this has very light atoms fission neutrons will have their energy reduced to thermal values in a relatively small number of collisions. Because of this, their chance of 'hopping over' a resonance in the 238 and so avoiding capture will be greatly increased.

Mixing natural uranium with a moderator in a homogeneous mixture, however, will not reduce the resonance capture sufficiently for a chain reaction to be self-sustaining. To achieve this the uranium must be separated into discreet lumps in the moderator, and a fast neutron leaving one lump can then be slowed down to below resonance energies before it reaches the neighbouring lump, so that resonance capture cannot take place.

NEW FACILITY AT IMPERIAL COLLEGE

Taken through a mirror to avoid incident radiation, this photograph shows the final stages in unloading the new 1100 curie cobalt source from Canada, which provides dose rates as high as megarads per hour. When the coffin plug is removed by a remotely operated block and pulley the source capsule is drawn into the stainless steel guide tube by a Teleflex cable

BOOKLIST—Electronics

Nuclear Radiation Detection. W. J. Price. McGraw-Hill. 1958. An excellent and readable introduction, containing all essential theory. Includes chapters on such electronic equipment as amplifiers, discriminators, scalers, etc.

Nuclear Radiation Detectors. J. Sharpe. Methuen. 1955. Much useful data for the designer and user of radiation detectors in this excellent summary.

Electronics. W. C. Elmore and M. Sands. McGraw-Hill. 1949. Deals with the design of electronic equipment, amplifiers, scalers, power supplies and oscilloscopes developed for the American Manhattan project. From some points of view the designs have aged a little—there is no mention of transistor circuits, but it is a book for the would-be designer to study.

The Measurement of Radioisotopes. D. Taylor. Methuen. 2nd Edn. 1957. Discusses the problem of radio assay, the apparatus and the methods used. An elementary account, but with detailed information.

An Introduction to Transistor Circuits. E. H. Cooke-Yarborough. Oliver and Boyd. 1957. Elementary account of the circuits required for nuclear measuring instruments utilizing transistors.

Reactor Control and Instrumentation. J. H. Bowen and E. F. O. Masters. Temple Press. 1959. An excellent introduction.

Radiation Hazards and Protection. D. E. Barnes and D. Taylor. Newnes. 1958. Deals with health physics and the associated measurement problems.

NEWSBRIEFS

- Science Masters' Association annual meeting Jan. 1 at Southampton considered urgent need for reappraisal of the teaching of atomic theory for "O" level course.
- Calder Operations School. Since Jan. 1957 when this course began 347 students have attended from 23 countries.
- Principles of radiation protection. Second Harwell Reactor School course commences April 20 for 11 weeks.
- USAEC grants to educational institutions now amount to over $12 million since the programme was started in September 1956. Main purpose is to help expand nuclear educational programmes at the graduate level.

UK COURSES—Instrumentation

Diploma and degree courses for graduates

Chelsea College of Science and Technology. M.Sc. 1 or 2 years. Sept. £30. Physical electronics. Electric and magnetic fields in vacuum; electrons and holes in semi-conductor devices.

Short courses for graduates and others

Harwell Reactor School. Durley Hall, Bournemouth. 2 weeks. May 23-June 3. £52 10s. Reactor instrumentation and control. Assumes basic knowledge.

London. Borough Polytechnic. 2 months. Part-time or full time. April 25-June 17. £2 10s. or £9. Nucleonic techniques and measurements. Main emphasis on lab. work with actual experiments to be done depending on the needs of the student.

2 weeks. June. £18 15s. Full time intensive course. Nuclear Physics. Mainly concerned with electronic instruments and application in reactor instrumentation, radioisotopes, etc.

6 lectures comm. April 28. Reactor instrumentation and control.

Other courses which include instrumentation

Belfast College of Technology. 2 weeks. June. Radioisotopes—handling and measurement.

Birmingham College of Technology. 6-8 weeks. £60. Nuclear power technology. Includes electronics and experimental work with counting and detection apparatus. (One course each term.)

2 weeks. June. £11 11s. Radiochemical techniques. Includes use of counting equipment, etc.

Letchworth. N. Herts. Technical College. 2 weeks. July. £15 15s. Radioisotopes—basic principles, handling and measurement.

Liverpool College of Technology. 2 weeks. March, May. £12. Radiochemistry. Includes counting techniques.

London. Sir John Cass College. 4 weeks. May. £30. Use and measurement of radioisotopes.

Whitehaven and Workington Colleges. 6 weeks. £65. Nuclear engineering. Full time. Complementary to 6 weeks Calder Hall course. Includes 10 periods on instrumentation.

Are present shielding techniques soundly based? A successful design is still often 'a triumph of inspired extrapolation from irrelevant data

SHIELDING DESIGN —theory and practice

by K. T. SPINNEY, B.Sc.
Leader, Shielding Group, A.E.R.E., Harwell

THE DESIGN of radiation shields has long been a subject in which guesswork, empiricism and faith have all played leading parts; the experimental confirmation of a successful shield design usually warrants rather more than the normal celebration since it often represents a triumph of inspired extrapolation from irrelevant data! Not that there is any shortage of good theoretical methods of calculating the penetration of radiation through matter: it is just that the theories usually apply to the wrong sort of matter. What is the use of a method of calculating the penetration of fast neutrons in a material which scatters isotropically, has no inelastic scattering, is infinite, homogeneous and uniform when, in fact, the real shield has none of these attributes and is pierced throughout by an array of fuel charge tubes into the bargain? Moreover, in a shielding calculation for a reactor, one is trying to decide how many of the 10^{10} neutrons (or gamma quanta) per square cm which enter one face of a shield actually emerge from the other side. One would like to know, for instance, whether this number is 1, 2 or perhaps as large as 5; such accuracy calls for unusually refined techniques and perhaps it is not too surprising that few exist at present.

When one turns from purely theoretical methods to empirical treatments based on experiment, one is handicapped by the fact that shielding experiments are neither cheap nor easy to come by; they usually require the use of a specially designed reactor or an accelerator, as well as involving a fairly large amount of structural engineering (a typical experimental shield array for bulk penetration tests would weigh up to 20 tons). Because of this, coupled with the fact that, understandably enough, shielding studies do not usually receive a major share of research effort, there are still a number of gaps in the data that would be needed to derive a really useful empirical approach to shield design.

OUTLINE

In designing shields for graphite power reactors by theoretical calculations the three major factors which must be known are neutron and gamma penetration into matter, and radiation streaming in ducts and voids. For the first, several limited methods have been available for some time and a new semi-empirical theory developed at Harwell looks promising for general applications. Satisfactory methods for calculating gamma penetration already exist using high speed computers. However, theoretical treatment of radiation streaming is still difficult and is at present restricted to empirical formulae derived from limited experimental results.

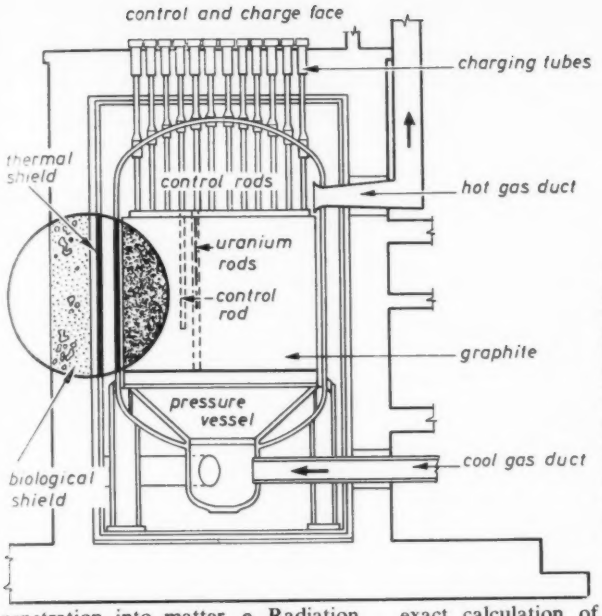
The main purpose of this article is to review the situation with regard to the availability and usefulness of current theoretical methods of shield design rather than to discuss the experimental position. It should also be pointed out that the emphasis throughout will be on methods of use in the design of shields for power reactors, with special reference to the gas-cooled, graphite moderated reactors of the UK civil power programme.

Problems in shielding power reactors

Before considering the available methods of calculation it is of interest to look briefly at the problems facing the shield designer of a gas-cooled graphite-moderated power reactor. Some of the more important of these, not necessarily in order of priority, are:

1. The provision of adequate bulk shielding for gamma and neutron radiation from the core and secondary sources in the shield itself.
2. The special problem of the reactor charge face shield with the complications of the many streaming paths for radiation which are caused by the penetration of the shield by the charge tubes.
3. The problem of radiation streaming through the large diameter (5 ft) gas coolant ducts and the scattering which takes place at their bends.
4. The activation of coolant gas and the provision of adequate shielding for its circuit outside the core.
5. The shielding of fuel charge/discharge machines which are in operation at full reactor power.
6. The problem of nuclear heating of the shield structure.

The relevance of some of the above items can be seen from the cross-section of a Calder Hall reactor illustrated in Figure 1. Methods of calculation required for tackling these problems may basically be reduced to three major subjects: **a.** Neutron penetration into matter, **b.** Gamma ray



Problems in the design of graphite moderated power reactors of the Calder Hall type shown here include streaming in the charge face shield and the gas ducts, shielding the active coolant and the charge machines, and nuclear heating of the shield structure (Fig. 1)

penetration into matter, **c.** Radiation streaming in ducts and voids.

NEUTRON PENETRATION

The problem of neutron penetration in the typical UK civil power reactor is somewhat paradoxical in that the only reason for studying the neutron distribution in the shield is to calculate the sources of gamma rays due to the (n, γ) reaction. It is the latter radiation which produces the greatest hazard from the shielding point of view and determines the overall shield thickness required. Both the gamma radiation from fissions in the core and the neutrons themselves are dominated by the intense beam of high energy gamma radiation which arises from thermal neutron capture in the pressure vessel, thermal shield and concrete bulk shield.

The first requirement then, for design purposes, is a practical method of predicting the thermal neutron flux distribution through a multi-layered shield, which, in a typical case, might consist of regions of graphite, steel and concrete. But it is just this facility which is so conspicuously lacking in current accounts of shielding theory. There are two basic reasons for this:

1. Neutrons, of any energy, which have penetrated to large distances from the reactor core (i.e. greater than 5 or 6 feet of typical shield material), started out their life from fission as high energy neutrons in the range 5 to 10 MeV and have covered most of the distance either without collision or with at most a few small angle elastic scattering collisions involving little energy loss. They have then slowed down to a lower energy near to the point of observation. The exact calculation of their behaviour during their high energy phase must take account of the anisotropy of elastic scattering, the energy losses due to inelastic scattering and the variation of the total mean free path with energy; all of these phenomena have a marked effect on the penetration process. This is a difficult problem.

2. When slowing down to thermal (or near thermal) energies, and after thermalization, the neutrons diffuse in an environment in which they are strongly affected by the moderating and absorption properties of the various shield media. Large and rapid changes in the thermal flux distribution can take place near the boundaries of different regions (e.g. between the graphite reflector and the steel pressure vessel). To be of any practical value a neutron theory must be able to cope with multi-layered shields composed of materials with widely different properties.

As mentioned earlier, there is no entirely satisfactory method available at present which meets both of the above criteria. But, in practice, the picture is not quite as black as painted since a substantial fraction of the (n, γ) sources in the shield arise from regions (e.g. the pressure vessel) which are close enough to the core for item (1) above to be irrelevant. Under these circumstances a reasonable estimate of the thermal neutron flux in this part of the shield can be obtained by means of two group diffusion theory and this is how most shielding calculations have been performed in the past. But this simplified theory breaks down at distances from the core of the order of 5 to 10 slowing down lengths for the reasons given in (1) above, and here a more sophisticated theory must be used if serious error is to be avoided. One way of doing this is to make use of empirical parameters in the two group equations for the outer shield regions (e.g. in the concrete bulk shield) but this reliance on *ad hoc* experimental data is obviously unsound and, in any case, is impossible when unorthodox shield materials are proposed. Some of the more promising methods which might overcome this difficulty are described below.

The method of moments

This powerful method, developed by Spencer and Fano at the National Bureau of Standards, USA (*1*) has been used to great effect on the problem of gamma ray penetration (*2*). It consists essentially of a semi-analytic technique for computing the spatial moments of the flux distribution which are then used to reconstruct the flux itself. It is less useful for neutrons, however, because of its very limiting restriction to infinite, uniform media; it therefore falls down on the second of the two criteria mentioned above, that of accounting for the effects of different media in a multi-region shield. But it does meet the needs of (1) and has already been applied to neutron penetration (*3*) in uniform regions of water, carbon, beryllium and in various hydrocarbons. Experimental verification has been obtained from fast dose measurements in water out to distances of 120 cm from the source (*4*). An excellent account of this method as well as other theoretical techniques is given in (*4*).

The Monte Carlo method

This method (*5*) consists of estimating the behaviour of neutrons (or γ-rays) diffusing in a medium by calculating the tracks of individual particles from the moment they leave the source until they penetrate the shield or are otherwise lost. The use of a high speed computer is obviously required and, in principle, one can deduce with any desired accuracy the actual flux distribution in the medium if a large enough number of tracks are determined. Although this would appear to be the answer to the shield designer's prayer since no restrictions are imposed on nuclear interactions or shield configuration, in practice there is a serious handicap in that the amount of machine time required increases rapidly with the depth of penetration and soon becomes prohibitive. Even with the so-called 'importance sampling' techniques by means of which great savings in time can be achieved, maximum depths of

penetration so far reported are only of the order of 8 to 12 mean free paths (*6*) (*7*). For high energy neutrons this corresponds to distances of about two feet in concrete, for example. This is far too small for use in power reactor shields when the total thickness (including reflector) is of the order of twelve feet. Further research is continuing on this method, however, and it may yet prove of use for deep penetration of neutrons. It is already of very great use in problems involving small penetration but awkward geometry (e.g. oblique penetration of thin shields, albedo problems (*8*) etc.).

Removal cross-section techniques

An empirical method which has proved to be of value in certain shielding applications is based on the use of so called 'removal' cross-sections (*9*). These are derived experimentally by measuring the change in the attenuation produced by a slab of the material in question when it is interposed between a fission source and a neutron detector in a large tank of water. The water is essential to the experiment since it has the effect of filtering out a narrow energy band of penetrating neutrons (8 to 10 MeV) and it is the effectiveness of the test material in 'removing' neutrons from this penetrating beam which is measured.

A characteristic cross-section is derived for the material which is termed the 'removal' cross-section and values have been published for a variety of materials (*4*), (*9*). In effect, this cross-section is a measure of the materials' power to attenuate the high energy neutron component mentioned in (1) above. It yields no information on the build up of lower energy neutrons or on the effects of shield boundaries on these. Since the characteristics of neutron penetration into water are well known however, removal cross-sections can be used to calculate the absolute intensity of the neutron thermal flux or fast dose inside regions of water which occur in a composite shield of water plus other materials.

It is important to realize the limitations of the method, which are:

a. It can only be applied when the neutrons are generated in a fission source.

b. It is relevant only to shields containing regions of water. (There is a possibility that it might also be of use in concrete regions but, in this case, only for the shape of the attenuation curve, not the absolute intensity.)

c. It gives no information on the neutron flux distribution inside the material itself but only in the water regions adjacent to it. Methods based on this type of energy independent removal cross-sections are of use in shields made up, for example, of steel and water slabs as used in marine reactors (*10*) (*11*) but their value in the prediction of thermal flux in a graphite/Fe/concrete power reactor shield is very doubtful.

A new method which has recently been used with success at AERE, Harwell (*12*) is to calculate the distribution of high energy penetrating neutrons in a shield by integrating over the fission sources in the reactor core using a point source kernel of the form $\frac{e^{-\Sigma_r(\varepsilon)r}}{4\pi r^2}$ where $\Sigma_r(\varepsilon)$ is an energy *dependent* removal cross-section, defined for energies in the fission spectrum (1 to 18 MeV) by the formula (*13*):

$$\Sigma_r(\varepsilon) = \Sigma_{tot}(\varepsilon) - \bar{\mu}(\varepsilon)\Sigma_{sc}(\varepsilon). \quad \ldots (1)$$

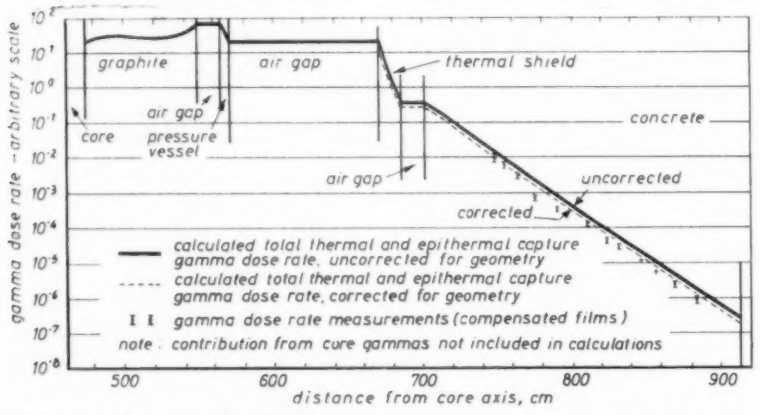
where $\Sigma_{sc}(\varepsilon)$ is the elastic scattering cross-sections,

$\Sigma_{tot}(\varepsilon)$ is the total cross-section,

and $\bar{\mu}(\varepsilon)$ is the mean cosine of the elastic scattering in the lab. system. In the evaluation of $\bar{\mu}(\varepsilon)$, hydrogen is treated as a special case with isotropic scattering.

Once the distribution of penetrating neutrons is found, it is used to generate a source term for slowing down which is then fed into a conventional multi-group diffusion theory in order to compute the build-up of lower-energy neutrons. This method, which is admittedly of a semi-empirical nature insofar as it treats the penetrating component, does allow adequately for the different materials in a multi-layered shield and does enable the absolute intensity of thermal flux to be computed throughout all the regions. The initial calculation of the penetrating neutron distribution has been programmed for the Mercury computer by D. E. Bendall (*14*). The multi-group calculation has also been programmed (code name RASH B), in the first instance by Dr. S. Linde (now at Aktiebolaget Atomenergi, Stockholm) with later development by J. D. Jones (attached to AERE from Vickers-Armstrongs Ltd.) A full description of the method is given in (*12*).

Some results of its application to the radial shield of a Calder Hall reactor are shown in Figure 2 in which the curve represents the intensity of the thermal flux in the shield as predicted by the method. Also shown are measured values obtained from manganese foils exposed in a 2 in. dia. hole which was drilled through the concrete bulk shield in stages as the measurements were made. Agreement is quite satisfactory in view of the order of attentuation involved, particularly as both were obtained independently and have not been normalized to each other. It would appear that the method is promising, at any rate, for shield configurations of this type.



The thermal neutron flux distribution at the mid-plane of the radial bulk shield of Calder Hall No. 1 reactor has been calculated at Harwell with the new removal theory. There is good agreement with measurements by manganese foils (Fig. 2)

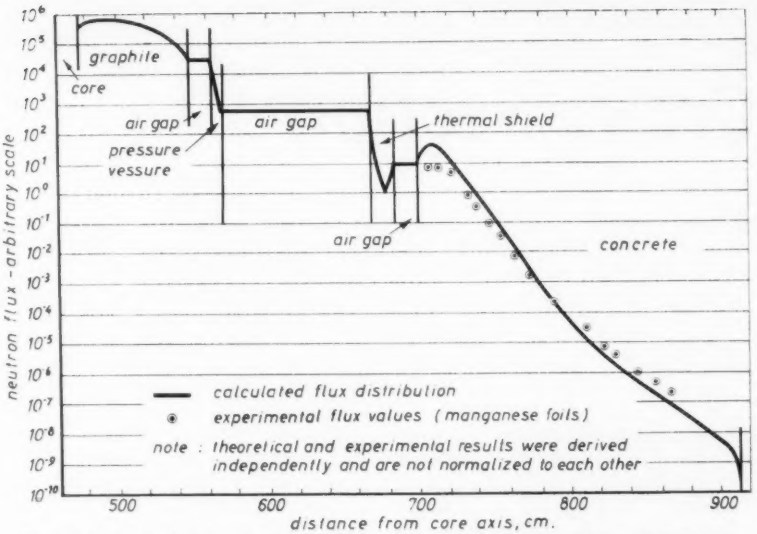
GAMMA RADIATION PENETRATION

In contrast to the problem of neutrons, satisfactory methods of calculating gamma ray penetration in thick shields already exist and, once the sources are known, the only difficulty is that of reducing the labour of all the tedious calculations which are required. Now that high speed computers are available even this hurdle has been overcome. The method which is universally adopted for such computations is first to evaluate the flux (or dose) of uncollided photons from the source in question and then to modify the answers by multiplying by a 'build-up' factor. This factor takes account of the effect of scattered photons and is obtained from published results of the application of the

method of moments which was mentioned earlier (*2*). Some error occurs because of the fact that these build-up factors are only calculated for infinite media (because of the limitation of the method) and they are applied to layered shields of finite thickness. But such errors are much less important than in the neutron case since material differences have a much smaller effect on the scattering of gamma rays than on neutrons and, in any case, one is not worried to the same extent about low energy gamma rays as one is about the all-important thermal neutrons.

A programme for the Mercury computer has been written by D. E. Bendall (*15*) which enables gamma dose rate or heat deposition rate calculations to be made throughout a multi-layered shield in plane geometry. The gamma sources may be either in the core or distributed through the shield itself as from the (n,γ) reaction. The programme is so designed that it will accept neutron flux data direct from the RASH B neutron programme mentioned earlier.

Some results of the application of this method to the Calder Hall shield are given in Figure 3 where the computed dose rate due to the (n,γ) reaction is drawn. Also shown are experimental results obtained from compensated films. Agreement is again satisfactory.



Theoretical calculation of gamma dose rate distribution in Calder Hall No. 1 reactor radial shield also agrees well with experimental values obtained with compensated films (Fig. 3)

STREAMING IN DUCTS AND VOIDS

This is probably the biggest single factor which hinders efficient shield design at the present time. Theoretical treatment of the problem is, for the most part, restricted to empirical formulae derived from a rather limited set of experimental results. Thus, although a fair amount of published experimental data has been accumulated on the passage of thermal neutrons through straight cylindrical or annular ducts, (*13*) (*16*) very little is available on fast neutrons (*16*) and none at all on gamma rays. When one turns to the problem of steps and bends in ducts, the position is even worse. Some measurements have been published on the effects of single steps on the streaming of thermal neutrons in rectangular slots (*16*) but the problem of multiple steps in annular ducts (which is the case met with in practice) has not yet been examined experimentally. Such theories as exist are much over-simplified and are of an empirical nature (*13*) (*17*). This is not intended to be adverse criticism of such work, which is, in fact, of great value in the interpretation of such experiments as have been made, but only to point out the lack of a unified, reliable method for design purposes.

As a result of these uncertainties, the shield designer must resort to making pessimistic assumptions whenever any doubt exists and then allowing further safety factors in his final answer to cover any errors. Thus it is usual practice (*12*) to assume that radiation streaming down an annular or cylindrical duct is attenuated, at distances large compared with the annular width, by a simple geometric law ($\propto 1/Z^2$) and that, when a step occurs, the radiation arriving at the step is transferred to the entrance to the next leg of the duct without attenuation. It is then assumed to continue with a further geometric attenuation starting from the step. The problem becomes more complex than this in a practical shield where one may have to deal with the case of radiation first passing through a pattern of holes in the charge pan of a reactor (at the reflector surface), crossing a large void, passing through further charge holes in the pressure vessel and then finally entering the annular ducts (containing several steps) in the concrete bulk shield. In problems like this, every designer does the best he can and, with the present state of knowledge on the subject, one can only wish him the best of luck! But, in fact, these problems are being studied at the present time and it is to be hoped that eventually a useful, consistent method will emerge.

This article has dealt with only a few of the outstanding problems of shield design but it must be apparant that the whole subject is still not yet in a tidy state. There is much to be done in both the theoretical and experimental fields before shielding calculations become a matter of routine. Only when this stage is reached can shield optimazation be performed with confidence and the economic gain, which this implies, attained.

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Acknowledgment :

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Cross Section by GRACCHUS

THE USSR-USA exchange agreement on atomic energy announced after the recent Khrushchev-Eisenhower discussions was thought by some cynics to be a rush job by the officials when disagreement had been reached on everything else. But it seems that it may come to something after all; I was very pleased to hear that the atmosphere was very cordial when Soviet and American atomic scientists later exchanged visits. At a meeting in Leningrad some good-humoured exchanges took place. Professor Spitzer, a leading American in controlled thermonuclear reactions learnt that a Soviet engineer, Mr. Stolov, had evolved new methods of investigating ultraviolet radiation of plasma and was working on the same processes discussed by Spitzer at Geneva. At the Atomic Energy Institute in Moscow, after examining Ogra, the assembly for the fusion of light nuclei, Mr. McCone, Chairman of the USAEC, was told that it took seven months to build and three months to design. He commented that such an operation would take two and a half years in the USA and wondered if the Soviets would make a similar machine for them. To make sure his complimentary remarks were not put down as light effusions of the moment he repeated them later in America: 'At the Soviet Atomic Laboratory at Obninsk, near Moscow, we were shown an advanced fast neutron experimental reactor fuelled with plutonium oxide. There are no such reactors fuelled with plutonium in this country nor elsewhere in the world. We were told that this plant was designed and constructed in a year. I have no reason to doubt this statement . . . the Russians' facility to direct and concentrate effort was ever apparent to us as we travelled from one technical institute to another.'

I SUPPOSE I am not alone in my fascination for the chicken barbecue, so many of which have sprung up all over the country, but the simple matter of ordering a portion of delectable roast seems to be threatened by a future complication: the appearance on the market of irradiated chickens. It may however be as well to enquire into the length of time since treatment. DSIR's 'Food investigation 1958' reports that chicken carcases treated with radiation remain good for about one and a half times as long as untreated carcases when stored at one degree C, although a slight 'but not objectionable' odour is apparent. A panel of tasters and domestic consumers declared that, after roasting, the flavour and texture of these irradiated chickens were seldom distinguishable from those of normal roasted chickens. After three weeks the treated carcase rapidly declined in quality and the roasted meat lost the attractive flavour characteristic of fresh chicken. It was also interesting to note that Danish bacon was far more amenable to irradiation than English bacon.

JUDGING by the copy of the bill of fare which they sent me, Salford Electrical Instruments' Nuclear Engineering Department had rather a strange Christmas dinner. Apparently though, it was eaten and enjoyed by the General Manager, the Chief Engineer of the Company, and some forty-six staff members and their families, and everyone was well enough to go on to a theatre afterwards. I list the items below:

PRIMARY COOLANTS

Half Life Beer
Gin and Toxic
'Standpipe' Whisky
Cadmium Cognac
Enriched Champagne
(In Magnox only)
Exhaust Port
Fertile Slurry
Hunter's Stone Ginger Beer
Digi Tizer
Cigars, Cigarettes and Matches may be obtained at the Geiger Counter

MENU

Brown Windscale Soup
Irradiated Turkey and Calderberry Source
With Compatible Vegetables
Critical Pudding with Heavy Custard
Mince πs
Graphite Corefee

CABARET

BERYL LIUM AND HER ISOTOPES
(Direct from the Salford Plutonium)

Most of them sound pretty awe-inspiring, but the one that really worried me was Brown Windscale Soup.

IT LOOKS as though a few changes may be on the way at the Atomic Energy Authority's London Headquarters. The new Chairman, who took over from Lord Plowden recently, turns out to be quite a tiger for work; people remaining long enough to see the light in his office still burning at about eight o'clock in the evening have been speculating on just what is brewing up there.

Since Sir Roger Makins' appointment was first announced many voices have been heard criticizing the Government for bringing in a career diplomat, but if we must have a civil servant in the job it is certainly better to have an energetic one. The growing size of the headquarters has come under intermittent fire and there may well be a case for more streamlining. At the same time the chairman's powers extend far beyond the London office and it will be interesting to see whether or not radical changes are made at Harwell.

ACCORDING to the last Treasury bulletin, industrial production is expanding in nearly all major industrial countries and, if demand moves as expected, primary producers as a whole will continue to expand their exports and be able to pay for imports. Listening to Sir Leslie Gamage, GEC's Chairman, at the recent AGM, I found him a little more cautious in his forecast for the electrical industry particularly with heavy engineering goods. European Free Trade would probably bring greater export chances but also pressure from imports. Sales resistance might build up as underdeveloped countries increased their degree of industrialization; this might be overcome by establishing joint ventures and exerting our efforts to sell British knowledge and ideas where we could no longer sell equipment alone, through 'know-how' agreements such as that on nuclear propulsion between GEC and MAN of Germany. The Americans have also done this in one way or another: Westinghouse and Framatome; Babcock and Wilcox and Indatom; General Electric and Alsthom of Belfort; and Atomics International and SACM of Paris, to mention only a few.

On Record

Will the fifties be called the age of the missing technologist, with employers appealing to him in advertisements across two newspaper columns?
Donald MacLachlan, Daily Telegraph.

A nuclear station is not such an offence to amenity as a conventional station with its ash disposal problem and with its coal stocks.
Sir Christopher Hinton.

Radiation sources for industry and research

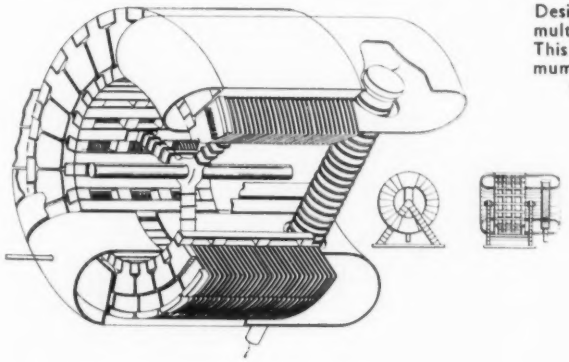
High Voltage accelerators now in world market

FOR A CONSIDERABLE time proposals have been made to many fields of industry to use intense radiation sources in their processes. Two methods can be employed; either a large isotope source such as has been installed by the UK Atomic Energy Authority at Wantage (see NUCLEAR POWER, *October* 1959, *p.* 110) or by employing a particle accelerator. One of the leading manufacturers of accelerators is the High Voltage Engineering Corporation, HVEC, of Burlington, Mass. In recent years they have made a large number of tandem Van de Graaff particle accelerators and while technical developments have been directed towards increased power and meeting specific requirements, attention has been focused on producing units which will be economical in use, especially for industrial purposes.

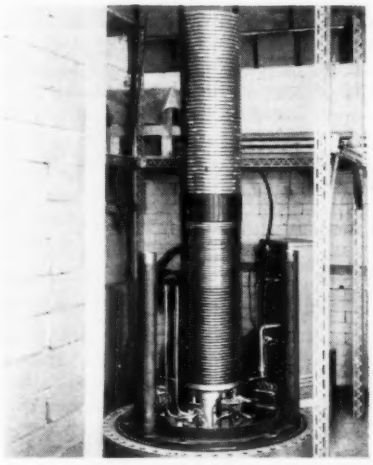
An expansion of the industrial use of ionizing radiation depends on the achievement of lower processing costs than those which are obtained from today's accelerators or those which can be predicted in the near future from nuclear sources. Power level is significant, because it is a divisor for process costs. Chemical reactions with low radiation yields may require 15 to 50 kilowatts of power at a moderate process through-put with costs below $1 per kilowatt-hour. Also, process streams of very large volume and of relatively low economic value, such as those encountered in chemical synthesis, may need 50 to 1000 kilowatts, even at high radiation yields with even lower costs. To meet these needs three new types of accelerators are being developed at High Voltage Engeineering Corporation. They are all 'direct' accelerators in which the generated voltage is applied through divider-resistors to an acceleration-tube system, but each embodies a different principle of voltage generation. Two are electromagnetic accelerators; the third accelerator is electrostatic. All would be practical for energies up to about 4 MeV and all are designed for beam currents greater than 15 milliamperes.

Basic types

The insulated core transformer accelerator utilizes a segmented magnetic core which permits large voltage buildups in the secondary windings of each segment without the requirement for high voltage insulation between winding and core, which is the limitation of conventional transformers. Each core segment, with associated windings and rectifier, is a compact d.c. power supply capable of delivering 30 kilovolts and 40 milliamperes of current. Voltage addition is obtained by distributed series capacitance between core segments. The overall efficiency of power conversion is about 90%.



Design features of a 1 MeV multi-disk accelerator. This form combines maximum disk surface area with compactness



A HVEC 1 MeV accelerator with tank removed. The acceleration tube is mounted below the transformer on the same axis

An electron accelerator utilizing this principle has been constructed and is now under test at HVEC's Burlington plant. This type of accelerator has the potential for delivering up to 1 MW of power and the generator can also be used to accelerate intense currents of positive ions for ion-plasma fusion studies or other research.

Another type of electromagnetic voltage generator developed by High Voltage is the 'transmission line' accelerator. It is an inherently simple device for obtaining over 20 milliamperes average beam current in the power range of 10 to 75 kilowatts, depending on energy range. A prototype is being constructed and power efficiency is expected to be over 80%.

The third type, a multi-disk accelerator, is analogous to the Van de Graaff accelerator in that voltage generated electrostatically. Its expected power range is 25 to 100 kilowatts. The first model is being constructed to deliver 15 to 25 milliamperes at 1·5 MeV

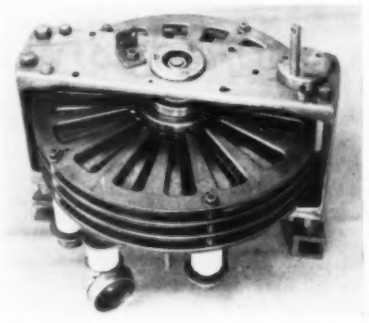
and the principles involved may also be used in the future to develop propulsions units for space vehicles by means of ion thrust.

Beam deflexion or diffusion has led to beam currents with less power absorption at the 'window.' In this connexion a 30-inch line scanning beam has been successfully used with a 1·5 MeV Van de Graaff accelerator to provide uniform coverage of wide film.

A new process being studied at High Voltage has been made possible through the availability of very intense radiation sources. Supervoltage power from a single generator can now be transmitted through insulated piping to independent, multiple acceleration tubes which are applied to a series of processing stages or to parallel production lines. In this way radiation shielding would be required only at the point of use. A similar concept may also be employed with microwave linear accelerators.

Practical applications

In addition to this development work, High Voltage are at present building three 12 MeV tandem Van de Graaff positive-ion accelerators for the US Atomic Energy Commission. These machines are to be installed at two of the Commission's laboratories, the Argonne National Laboratory and Oak Ridge National Laboratory and at the Rice Institute, Houston, which



Model of a multi-disk generator. Each of the two surfaces of a plate with a radial depth of 1½ ft. and moving at 1800 rev/min. can develop 300 microamperes

is carrying on nuclear physics research under contract to the AEC. While the three units are of the same basic design they will be equipped with different components and accessories to meet the varying needs of the separate institutions. The total cost of this work will be in excess of $M3 and installation is scheduled to be completed by mid-1961.

On the export side, HVEC are also very active and two 10 MeV accelerators are at present under construction; one for Switzerland and one for Australia. Under a Swiss Government supported programme, one machine is to be installed this year at the Kernphysik I Laboratory of the Institute of Technology at Zürich and will be used for basic nuclear research. The other is to be installed at the Australian National University at Canberra and will be used in experiments with hydrogen and deuterium bombardment of light and heavy elements.

In this country, a number of companies are actively investigating the use of accelerators in their processes and successful results have been achieved for the cross-linking of plastic materials and the sterilization of medical dressings and syringes. For the future, these machines may play a big part in other industrial fields, including that of food processing.

PROGRESS IN INDUSTRY

Development of rare metals for industry

new materials must operate under extreme conditions

INTENSIVE research over the past seven years has resulted in a number of new metals becoming available to industry. The metallurgists at AWRE, Aldermaston, for example, started a development programme for beryllium in 1953 when it was envisaged that this material would be suitable for improved nuclear fuel canning. Work has progressed to such an extent that beryllium is now a serious contender with titanium for a number of applications; its advantages are that it is lighter, has better heat conductivity and a considerably higher rigidity to weight ratio. Already it is being considered for such uses as aircraft disk brakes and high temperature ancillary reactor components.

The AEA have developed casting and powder metallurgy techniques, together with extrusion and rolling processes, as methods for fabricating rod, tube and sheet. Electron-beam welding, argon-arc welding and flame brazing are among the methods which have proved successful in the joining of beryllium.

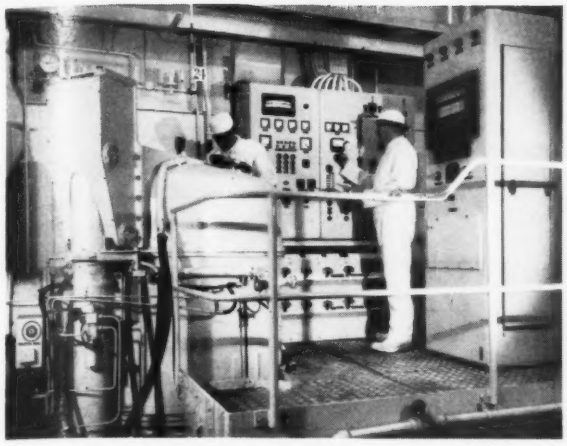
At the present time, beryl, the principal source of beryllium, is exported mainly from Brazil but increasing quantities are now coming forward from Uganda. During the first nine months of 1959 some 13 tons, valued at £14,285, were despatched against approximately 8 tons, valued at £8308, for the whole of 1958. Metallic beryllium is separated by a three-stage extraction process which produces beryllium 'flake' or 'pebbles.'

First in Europe

During 1959, the Metals Division of the Imperial Chemical Industries Ltd. completed a £M10 programme for the development of 'new metals' production at Witton. This project included the commissioning of the first wrought beryllium plant in Europe, as well as the first titanium melting and fabrication plants in the United Kingdom and the largest zirconium plant in Britain.

While the beryllium project is purely an industrial operation financed entirely by ICI, the plant incorporates all the safety recommendations that have resulted from experience gained both by the UK Atomic Energy Authority and the US Atomic Energy Commission and will operate as a research production unit; initial output will be about seven tons a year. At present a two-shift system is being worked but in the immediate future three shifts will be initiated.

To produce beryllium with good mechanical properties, impurities must be removed and powder metallurgy techniques used to reduce the grain size. The raw material in the form of beryllium flakes is made into pellets, then vacuum-cast into ingots. These ingots are completely machined down and the swarf subsequently ground to powder which is then packed into graphite moulds and sintered at high temperature under vacuum. The consolidated beryllium is machined into slugs, electro-plated and extruded into tubes and rods. Following cutting and straightening to requirements the components are inspected and prepared for despatch. Throughout these oper-



Vacuum furnaces are used for sintering and consolidating the beryllium powder under clean conditions before extrusion

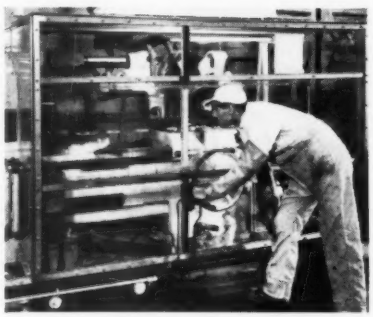
To maintain high purity of the raw materials and beryllium metal content, analytical and radiographic inspections are carried out in these dust-control compartments

ations, complete dust control and monitoring is maintained to prevent any contamination from beryllium dust.

Parallel with the work being carried out by ICI is the production of beryllium tubing by Tube Investments' subsidiary, The Chesterfield Tube Co. Ltd. (see '*Industrial Newsdesk*,' January). Already a contract has been completed by Chesterfields for fifty small bore tubes, each 5 ft long.

Large zirconium output

The first of ICI's production units for the 'new' metals was brought into operation in 1958. This was for zirconium which was the first structural metal to be developed on a commercial scale specifically for the nuclear engineering field. One of their alloys, zirconium-20, is being used for fuel sheathing and for structural components in the British nuclear-propelled submarine *Dreadnought* and other alloys are being developed to



An intermediate stage in pure beryllium production is to reduce the ingot to chips on this swarfing lathe

suit conditions experienced in GCRs and SCRs. The normal weight of zirconium ingots has been approximately half a ton but ingots up to as much as three tons can now be produced.

From the commercial aspect, titanium production completes ICI's output of the 'new' metals and over the past five years the manufacturing techniques have been so improved that ingots of up to 4200 lb in weight can now be made as against the original 400 lb ingots. The new plant has an annual capacity of some 2000 tons of titanium. On the research side, the Metals Division has set up a New Metals Section which is carrying out an extensive programme not only on beryllium, zirconium and titanium but also on other newer metals, specially hafnium, niobium and vanadium. The two latter have already been used experimentally as sheathing materials in the fast breeder reactor at Dounreay. Niobium alloys with good oxidization resistance up to 1230°C are being developed which should be of particular value in future high temperature reactor projects.

The 'new metals' are now available from ICI on a commercial basis. Here, a 2100 lb titanium ingot is rough-machined before forging

Centralized remote control is employed in the melting of titanium ingots and progress is followed by means of an optical system for each of the three furnaces

New Product Survey

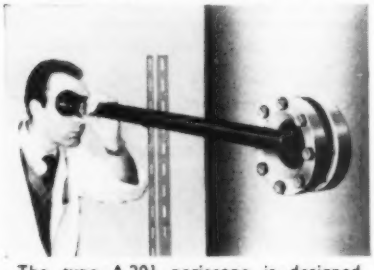
PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

REMOTE VIEWING

safety periscope

A new safety periscope has been added to the extensive range of remote and indirect viewing equipment made by P. W. Allen & Co.

The Allen A.201 periscope uses an optical system of unit power with a field of view of 35°, fully corrected and free from distortion. The optics are contained in a metal tube 30 in. long and 1½ in. diameter fitted at one end with a rubber eye shield and focusing sleeve and at the other a 90° prism. Objects



The type A.201 periscope is designed for the safe viewing of equipment and processes through sight glasses in pressure vessels, furnaces, chemical plants etc.

between 3 in. and infinity from this prism can be focused, with great depth of focus at any setting.

A 90° eyepiece is available for use when the periscope has to be held horizontal at a level lower than the eye. Low-voltage high-intensity spot lights are also available to fit on the end of the periscope when necessary.

Tick **No 208** on reply card

CONTAMINATION MONITOR

fully transistorized

E.M.I. Electronics has produced a new compact all-transistor contamination monitor. The instrument employs E.M.I.'s dual phosphor technique by means of which both alpha and beta contamination can be monitored simultaneously. Separate distinctive tones are provided for alpha and beta, either on headphones worn by the operator, or through a built-in loudspeaker.

The E.M.I. Portable Contamination Monitor Type 1 is claimed to provide high accuracy over a temperature range 0°C to 45°C. By using a single switch it is possible to monitor alpha plus beta or either separately. Counts per second are displayed on a meter covering the range 0–5000.

A high-pitched tone indicates alpha contamination and a low tone beta. Both notes are heard when alpha and beta are monitored together. When the type of contamination has been identified an accurate check can be made on either the alpha or beta positions. For monitoring very low alpha activities an electro-mechanical register is included to give a more accurate display at rates below about 6 per second.

The overall dimensions of the unit are 11½ in. × 8 in. × 8½ in., its weight approximately 11 lb., and power consumption ¼ W.

Tick **No 209** on reply card

RADIOGRAPHY

betatron for 20 in. steel

The Brown Boveri betatron is now marketed in the UK by Watson & Sons (Electro-Medical) Ltd. The radiation energy is adjustable up to 31 MeV and in some models up to 35 MeV.

Steel can be radiographed up to a thickness of 20 in. At full output and focus to film distance of two metres, radiographs of 8 in. of steel can be obtained in four minutes with a density of two, and in thirty minutes with 12 in. of steel. The instrument has two focal spots, each 0·1 mm × 0·3 mm. The wire penetrameter (DIN) sensitivity over a thickness range of 6–14 in. of steel is almost constant at 0·3%. At 10 in. steel a 0·03 in. dia. wire can still be seen. The very small focus size allows X-ray magnification to be used, and thus further improvement in sensitivity can be obtained.

The power consumption is 16 kW and cooling is by a built-in fan. The basic X-ray head can be rotated by motor drive about horizontal and vertical axes,

In addition to radiography, the Brown Boveri betatron can also be used for nuclear physics studies, including photo-nuclear reactions and generation of Cerenkov radiation

and mounted on a crane or gantry. Auxiliary equipment includes a condenser bank and cabinets containing electrical equipment for electron injection and orbit expansion.

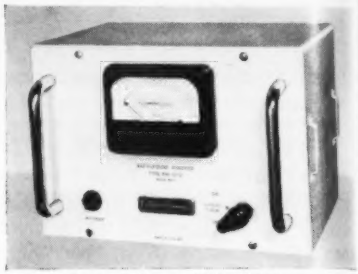
Tick **No 210** on reply card

PORTABLE MONITOR

background surveys

A new lightweight portable monitor for the measurement of background radiation has been designed and developed by Plessey Nucleonics.

Detection is accomplished by a built-in halogen-quenched geiger-müller tube



The Plessey Type PNI 1072 monitor has been designed to fill the frequent need for an accurate means of measuring any background activity quickly and easily

with measurement on a transistor rate-meter giving direct reading of dose rate on a 2½ in. scale moving coil meter. The instrument has a range of from 0 to 3 milliroentgens per hour on a two decade quasi-logarithmic scale, with a minimum scale calibration of 30 microroentgens per hour. The unit is powered by a 9 V dry battery and weighs only 8 lb.

Tick **No 211** on reply card

VACUUM REFINING

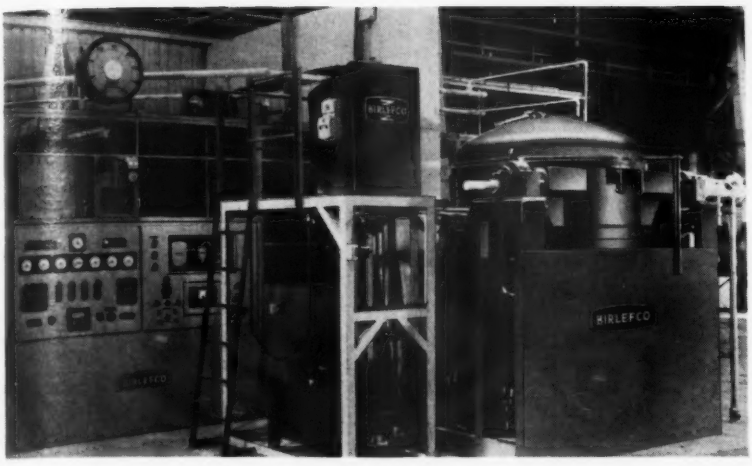
mains frequency furnace

A new vacuum melting furnace has recently been installed by Birlec-Efco (Melting) Ltd. at the Birmingham works of Henry Wiggin for refining special alloys. Basically it is a 15 cwt, 300 kW mains frequency induction melting furnace housed in a tiltable vacuum tank.

Mains frequency was chosen not only because of the greater turbulence which compared with h.f. equipment but also because of the greater turbulence which is produced in the molten metal. This brings new metal to the surface where gases and volatile metals can be drawn off.

A typical vacuum refining cycle occupies about one hour. Liquid metal is brought to the furnace by ladle and when the furnace is charged, hydraulic gear lowers the lid into position over the chamber and pneumatic clamps lock it in place. The chamber pressure is then reduced to about 200–300 microns in about 15 minutes.

During refining, sufficient power is applied to the furnace to ensure thorough



In the Birlefco mains frequency furnace, the tank is mounted on trunnions and tilted by hydraulic cylinders. Automatic controls are incorporated in the three-stage pumping system

stirring of the molten metal and to maintain temperatures at the desired value.

After vacuum treatment, air is admitted back into the furnace, the hydraulic gear raises the lid and the retractable spout is placed in position. The temperature of the metal is adjusted and checked by dip thermocouple and various other checks are made, after which the furnace tilts, pouring the vacuum refined metal into a ladle for casting or teeming in the conventional way.

Tick **No 212** on reply card

PULSE AMPLIFIER

6-position gain selection

Ekco Electronics have announced a new general-purpose high-stability pulse amplifier, Type N640, with a wide frequency response. It is designed for use with scintillation counters without built-in amplifiers and will drive ratemeters and scalers requiring an input of 5 V or more.

A six-position gain selector is incorporated and the low impedance output is positive-going for a negative-going input. A simple modification enables negative-going output to be obtained if so desired. Power supplies are obtained from the associated ratemeter or scaler. It has a gain approximately constant from 50 c/s to 200 Kc/s and the upper half-power frequency is 1 Mc/s.

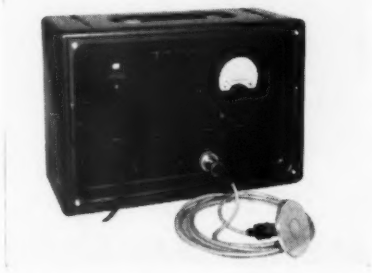
Tick **No 213** on reply card

DISTANCE METER

remote measurement

The Wayne Kerr Distance Meter DM100 operates in conjunction with non-contacting probes to provide a basically linear method of measuring distance from 50 micro-inches to half an inch. Distance is read directly from a moving-coil meter, the full-scale range depending on the probe in use. The four probes available cover full-scale ranges of 1, 10, 100 and 500 thousandths of an inch. Claimed accuracy is ± 2% F.S.D., with discrimination better than 0·5% F.S.D.

The length of the probe cable is 10 ft, enabling the instrument to be situated



The instrument uses a high-gain amplifier with a negative-feedback loop completed by the capacitance between probe and test structure. Meter reading is directly proportional to the probe/structure separation

well clear of the test structure. An outlet from the front-panel is provided for connexion to recorders or servo-control systems. Direct indication of expansion is obtained without imposing any load on the item under observation. One application is the measurement of verticality in reactor control rods.

Other applications include any distance measurements of up to half an inch where direct-reading and continuous monitoring facilities are required, the routine inspection of piece parts and all *in-situ* measurements during machining operations. The instrument can be set up to give automatic rejection of out-of-tolerance parts.

Tick **No 214** on reply card

LOW-LEVEL BETA COUNTING

latest Philips instruments

Research and Control Instruments Ltd., sole distributors in the UK, have announced a new Philips Low-Level Beta Counting Arrangement (PW.4127). Designed to measure low specific activities of radioactive materials, it has a background count of only 1·5 per minute.

Special features include a new type of guard counter, a sample counter of extremely thin window (1·5 mg/cm²), motorized sample drive and low specific-activity lead shielding.

Available for operating electronically, the Low-Level Beta Counting Arrangement is a new Philips Anti-Coincidence Unit (PW.4092). This consists of a 'count' channel and a 'guard' channel. In operation, detector pulses are supplied to the 'count' channel. This comprises a pulse amplifier and three pulse shapers. The second shaper provides for a delay of 3 microsecs. The last supplies pulses with a length of 3 microsecs.

The 'guard' channel receives pulses from the guard counter(s). This channel consists of a pulse amplifier and two pulse shapers. The length of the output pulse of the last shaper can be varied in steps by altering the value of one of the capacitors of the circuit.

The pulses of the 'guard' channel block the circuit for a certain length of time determined by the output pulse length of the channel. During this period, the pulses of the beta counter are not passed on to the output and, consequently, do not reach the scaler.

Both 'count' and 'guard' channels have a separate output, so that both background count rate, and sample plus background count rate, may be observed.

Tick **No 215** on reply card

IN BRIEF

Liquid scintillation counter. Low cost model (LSC-10) from Tracerlab Inc. (U.S.A.). With semi-automatic sample changing, it holds forty 20 ml sample vials. Main application—low-energy beta-emitters.

Tick **No 216** on reply card

Arc-welding. Two new machines from Dohm Ltd. *Midget* gives 160 amps on 50 V open circuit—has 15 variations of output current and is suitable for 8-16 gauge electrodes. *Twin Midget* has 52 variations of output—maximum is 320 amps with one operator.

Tick **No 217** on reply card

Electric Motors. New range of totally-enclosed, fan-cooled a.c. motors with class E insulation from Crompton Parkinson. Designated series 5 T.E.F.C., they are smaller, lighter and cheaper than the machines they supersede. Powers cover 1 to 40 h.p.

Tick **No 218** on reply card

They said...

points from papers, speeches, conferences

North American policy for next year

On January 18 President Eisenhower delivered to the United States Congress his Budget Message for the fiscal year 1961. During a fairly detailed review of proposed nuclear activities he made it very plain that it was the US Government's intention to increase development resources at the expense of the American and Canadian uranium producers. The President said 'In 1961 the expenditures for the AEC are expected to remain at the 1960 level of about $M2700. Substantial increases for research and development activities will be offset by reductions in procurement of uranium ore concentrates from the US and Canadian producers. These reductions will bring ore supplies into better balance with production requirements.'

'Development and production of nuclear weapons in 1961 will remain at the high levels of previous years and . . . when the land-based prototype reactor for a destroyer is placed into operation in 1961 along with the four other naval prototype reactors now operating, nuclear power plants will be available for all major types of naval combatant ships. Emphasis in naval reactor development in 1961 will be placed primarily on development of improved and longer lifed reactor fuel. The development of nuclear ram-jet engines for missiles, of nuclear aircraft engines and of nuclear electric power plants for use at remote military bases will be carried forward.'

Industrial applications

Turning to the Government's part in developing nuclear power for commercial purposes, President Eisenhower said that estimated expenditure would be around $M250, of which $M185 will be for research and the balance for the construction of civilian power reactors and related development facilities. Included in these estimates are new appropriations of $M40 for assistance to private and public power groups for developing and building demonstration nuclear power plants. The number, type and size of reactors to be built will be determined by the AEC (*see 'AEC financial report for* 1959,' NUCLEAR POWER, *January* 1960, *p.* 77, for AEC's current deployment of reactor types).

In support of the US civilian space programme, the President said that the AEC will 'continue development of nuclear-powered rockets and small long-lifed nuclear power sources for space vehicles. Development work on thermonuclear power and on applications of nuclear explosives to a variety of civilian uses will continue in 1961'. All in all it is apparent that the United States Government intends to continue the advancement of its nuclear technology on the widest possible front.

PRESIDENT EISENHOWER
cut uranium from Canada

Second thoughts in Canada

Criticism of the present official policy continues to grow in Canada. The controversy that became public at a meeting of the Ottawa branch of the Engineering Institute of Canada towards the end of last year (*see They said, December,* 1959) has been aggravated by present uncertainty over the production of uranium. President Eisenhower's comments cannot be very encouraging to the Canadian producers and during the 'Forum of Public Opinion' of the First Canadian Conference on Uranium and Atomic Energy, held in Toronto in the middle of January, reappraisals of policy for both uranium production and types of power reactor were strongly advocated.

Mr. Winnett Boyd, President of Winnett Boyd Ltd., said that 'while practically all of the countries of the world have expressed great interest in the progress and outcome of Canada's natural uranium, heavy water experiment none has been willing to take a similar financial gamble. And this gamble will amount to not less than $M210 over the next five years besides running the risk of being eliminated from the reactor export business and losing five valuable years in getting into the enriched uranium business.'

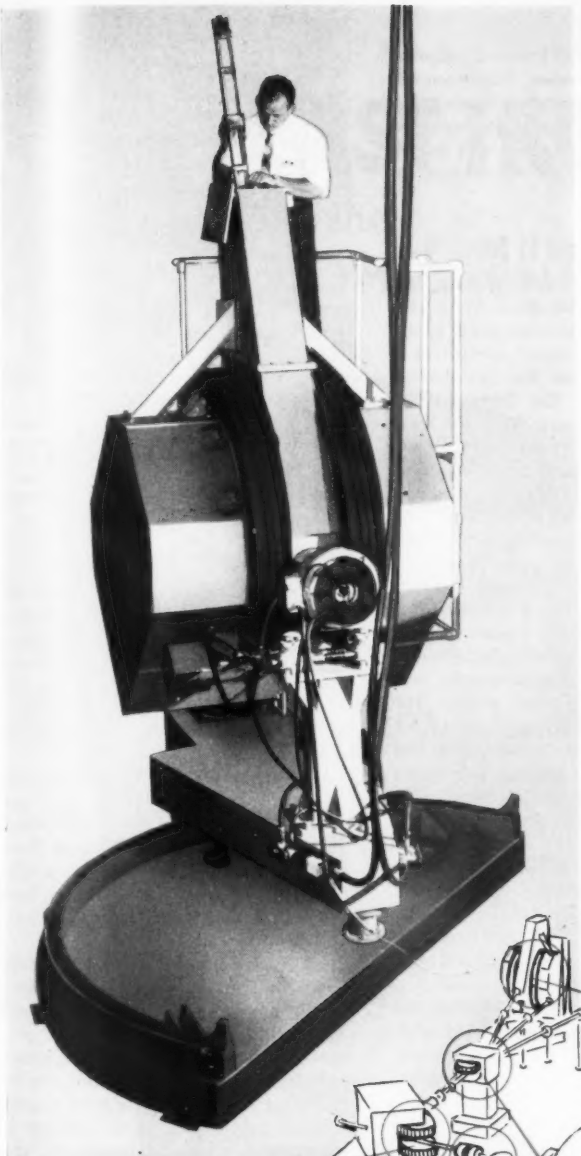
What about safety ?

Another point Mr. Boyd made was 'how safe is the Candu reactor and are adequate safety provisions being made? In view of the NRX accident of a few years ago and the fact that neither NPD-2 nor Candu are to be provided with containment vessels, as required for practically all American liquid-cooled reactors, Canadians have a right to seek re-assurance on these vital questions'.

To review the situation officially, the Canadian Government propose to investigate the nuclear policy and a parliamentary committee has been set up for this purpose. Discounting the attendant political disagreements, the technical press of Canada are all agreed that drastic action is necessary if the uranium industry is to maintain its present vigour after 1962. They feel that already the UK is veering from the natural uranium concept and doubtless other countries will shortly be following this lead. It would appear, therefore, that if the Canadians wish to keep their position they have a lot of rethinking to do. Canada could not compete in the world markets as an exporter of heavy water but she could export enriched uranium. To follow this course it will be necessary to modify her concepts of power reactors.

Liquid fuel success

Returning to the United States, a rather more optimistic note was struck by Alvin M. Weinberg, director of Oak Ridge National Laboratory in his annual 'State of the Laboratory' at the end of 1959. He said that 'it has been proved to the world that a high pressure, aqueous-homogeneous, circulating-fuel reactor is a tenable engineering device'. The Homogeneous Reactor at ORNL has been operated at various powers up to 5 MW for 78% of the last six months and Mr. Weinberg stated that in the current run the reactor cell has been sealed with the circulating pumps running uninterruptedly for 1600 hours, a feat which begins to approach the longest uninterrupted run of any power reactor in the world. He said 'the importance of the achievement is emphasized in the fact that the world has been reluctant to take fluid fuel systems seriously.'



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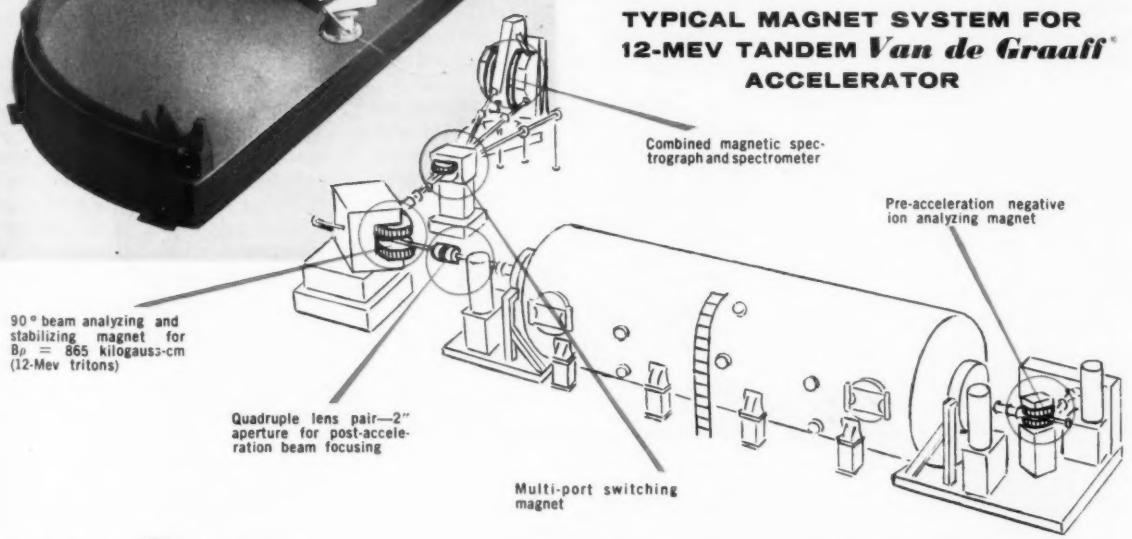
- Detector —
  Nuclear track plate and scintillation counter

*For further technical reference, see H.A. Enge, RSI **29**, 885 (1958)

TYPICAL MAGNET SYSTEM FOR 12-MEV TANDEM *Van de Graaff*® ACCELERATOR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INDUSTRIAL NEWSDESK

Companies consolidate

Elliott-Automation Ltd. have purchased Isotope Developments (Beenham) Ltd., a subsidiary of Isotope Developments Ltd. The activities now being taken over cover industrial and research instrumentation in which radioactive isotopes are employed. It is intended to change the name of Isotope Developments Ltd. to Nucleonic Investments Ltd. which will continue to be the owners of R. A. Stephen & Co. Ltd. Another company bought by Elliott-Automation Ltd., this time to widen their interest in control valves, is Black Automatic Controls Ltd. of Corsham, Wiltshire, manufacturers of a range of control valves and pressure regulating equipment. This brings the number of valve makers in the Elliott-Automation Group of twenty-five companies up to four.

To facilitiate administration and control, John Brown & Co. Ltd. have transferred all the activities of its special engineering and nuclear division to a new wholly-owned subsidiary company, John Brown (S.E.N.D.) Ltd. Again to consolidate operations in the nuclear field, the activities of Head Wrightson Processes Ltd., a subsidiary of Head Wrightson & Co. Ltd., have been extended to cover all Head Wrightson's nuclear research and nuclear power interests. Headquarters for this work have now established at Yarm-on-Tees in Yorkshire.

So as to benefit from greater financial resources for expansion and development work, the Solartron Electronic Group Ltd. has become a subsidiary of Firth Cleveland Ltd. From a technical point of view, however, Solartron will continue as an independent organization and existing arrangements for technical and commercial cooperation with British and overseas companies will remain unchanged.

American know-how in UK

A three-man team from Dunlap and Associates, Inc. of Stamford, Conn., are to undertake a human-engineering analysis relating to the central control of a nuclear power station for the Atomic Energy Division of The General Electric Co. Ltd. The team, led by Jerome H. Ely, Ph.D., an assistant vice-president of the American company, will take four weeks to complete its work at Erith. The object of this analysis is to ensure that new designs are compatible with known human limitations and capabilities.

During January an agreement was concluded between Kelvin & Hughes Ltd. and the Curtiss-Wright Corporation of America for the exclusive right to manufacture and sell the non-destructive testing equipment of the other partner. The range covered includes instruments for the inspection and measurement of materials and units employing ultrasonic techniques in all industrial fields.

American material handling equipment which has been developed and patented by the Fried Steel Equipment Manufacturing Corporation of New York is now to be made available in the UK. Weldall & Assembly Ltd. have recently entered into a licensing arrangement with the American designers.

Development work on the tungsten arc process is being undertaken by British Oxygen Gases Ltd. who are now marketing the equipment under an arrangement with Union Carbide Ltd. This process is used for form-cutting readily oxidized metals, such as aluminium, stainless steel, titanium and copper, and produces an edge which is metallurgically clean and free from contamination.

INTEGRATED CONTROL SYSTEMS. De Havilland Propellers have developed this Data Acquisition and Monitoring Equipment, DAME, to investigate process problems. The three cabinets contain executive controller, programmer and normalizers

Britons go overseas

The Russian Trade Delegation has placed an order, valued at £16,000, for thirteen Griffin & George gas-liquid chromatographic analysis units. This is the second order from the USSR during the last twelve months for this type of apparatus; the initial contract was for six instruments.

As a result of an agreement recently concluded between Pantak Ltd. and Usines Balteau of Liège, two new ranges of lightweight portable industrial X-ray equipment are now available in this country. Of these a 180 kV unit has been specially developed for the examination of circumferential welds.

Under a new agreement between Cockburns Ltd. and Ateliers et Chantiers de Bretagne of Paris, the French company will manufacture Cockburns' products for marine, industrial and atomic applications and will act as selling agents for France and Algeria. Under a reciprocal arrangement, Cockburns Ltd. are to manufacture special compressors and evaporators to the French company's designs.

Looking westwards, E.M.I. Electronics Ltd. have recently come to a marketing arrangement with the Canadian General Electric Co. Ltd., whereby television equipment of British design will be available in the Canadian market. For use in electronic computers, Londex are now marketing a range of miniature relays manufactured in West Germany and it is anticipated that in the near future this type of relay will be made in the UK to the German design.

US fuel picks up

Over the past month American nuclear fuel interests have received five worthwhile contracts. The Mallinckrodt Nuclear Corporation is to produce uranium fuel for half of the second core for the NS *Savannah*. Worth some $M3, the con-

HINKLEY POINT. Two years since site work started the first of the twelve 300 - ton boilers goes into position for the 500 MW nuclear power station

CAST IRON VESSELS

for the ATOMIC ENERGY AUTHORITY

Approved by Lloyd's for Class II welding for pressure vessels

One of the battery of special Cast Iron Vessels supplied to the U.K. Atomic Energy Authority. The body of the vessel is approximately 5ft. 8in. outside diameter by 6ft. 3in. high and the complete vessel weighs approximately 30 tons.

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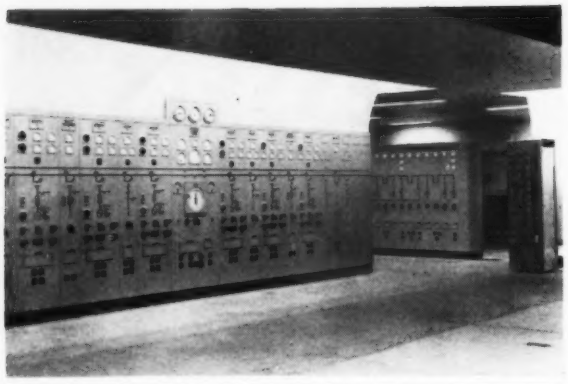


A FINISHED LOOK. At Bradwell nuclear power station the instrumentation in the turbine house control room is nearing completion

tract calls for 14,175 lb of 3·9% enriched uranium dioxide in powder form. Delivery to the General Electric Co. for further fabrication into fuel elements commenced early in January.

The Nuclear Division of The Martin Co. has received a contract for fuel elements from the Allis-Chalmers Manufacturing Co. for the 22 MW BWR they are building at Elk River. Martin will supply 148 bundles which will form the core and 22 bundles 'spiked' with a greater amount of U-235 for supplementary loading. Each bundle will consist of 25 stainless steel tubes, slightly over 5 ft long loaded with ceramic pellets composed of a mixture of uranium oxide and thorium oxide. Delivery will start mid-1960 and be completed two or three months later.

A replacement core for the research reactor of the Battelle Memorial Institute has been ordered from the Babcock & Wilcox Co. It will consist of 27 plate-type fuel elements and six control elements. Each element will consist of highly-enriched uranium alloyed with aluminium in curved plate form.

Another contract received by the Mallinckrodt Nuclear Corporation covers the manufacture and supply of uranium material for the reactor core of HMS *Dreadnought* and it is the first time fuel for a naval warship has been supplied by any commercial non-government source. The Westinghouse Atomic Fuel Department will subsequently fabricate the fuel elements.

Effective March 1, 1960, a uranium purchase contract has been placed with the Cotter Corporation by the AEC. This will enable the pilot plant at Canon City, Colo., to be expanded into a full-scale processing mill and the daily rated capacity is expected to increase from about 50 tons to some 200 tons. This contract represents a further step in AEC's policy of expanding domestic uranium supplies.

In brief

Valves for Windscale. The AEA have ordered five sets of combined change-over and safety valves for service with radioactive CO_2 in the AGR where they will be operating at 760°F.

Helping industry. The Battelle Memorial Institute is now willing to accept a larger number of specimens from industry for irradiation studies.

Exports to Russia. W. G. Pye Ltd. have completed delivery of nine argon chromatographs, worth some £7000, to the Soviet Union.

First boiler for Indian Point. The first of four 60-ton heat exchangers for the 275 MW PWR Consolidated Edison plant has been delivered by the makers, Babcock & Wilcox Co.

Berkeley equipment. The GEC is to supply a power-operated manipulator to the CEGB to form part of the laboratory equipment being installed by the main contractors, H. M. Hobson Ltd.

Graphite at Dounreay. The special borated graphite blocks for the fast breeder reactor were made and machined by The Morgan Crucible Co. Most of the blocks contained 0·3% boron but some contained 5% and altogether some 500 different patterns were machined.

Saving time. The US National Bureau of Standards is using high-speed computation in the preliminary stages of designing the core of a high-flux research reactor. Of the two codes being used, one, Wanda, is solving in two minutes what would take two or more days by hand, and the other, PDQ, solves two-dimensional problems which would be impossible to solve by hand.

Russian ideas. Copies of original Russian patents and special translations are now available in the UK from the Technical Information Co.

Cheaper polythene. Alkathene, ICI's brand of polythene, and its compounds have been reduced in price by 3d. per lb.

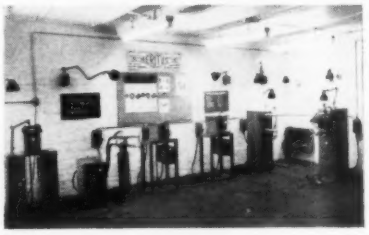
AEA's artificial element. The Authority has perfected a process to extract from waste fission products, the element technetium which cannot be obtained from natural sources. To produce some 20 grams of pure technetium over hundred tons of waste had to be processed.

New electronics subsidiary. So as to be able to participate on a bigger industrial scale, Lockheed Aircraft Corporation have formed a new company, the Lockheed Electronics Co.

Fuel fabrication. The Electric Resistance Furnace Co. Ltd. has received an order from the AEA for six Efco-Lindberg furnaces which will be used for the heat treatment of fuel elements.

New contract form. A new model form of General Conditions of Contract has been prepared by the Joint Committee of The Institution of Mechanical Engineers and The Institution of Electrical Engineers, for use in export work.

New films. Shell-Mex and B.P. Ltd. have just issued two new films; 'An Industrial Notebook on the Generation and Distribution of Electricity' which fully covers the problems of shipping the boilers for Bradwell; and 'Liquified Petroleum Gases in Industry' which shows the application of protective atmospheres in heat treatment furnaces.



WELDING TECHNIQUES. Meritus (Barnet) Ltd. have recently opened this demonstration workshop to assist users in the most efficient use of their machines

New primer for CEGB. A graphite primer, PA21, made by Federated Paints Ltd. has been approved for use on the inside surfaces of the gas circuit at Trawsfynydd power station.

Marine coordination. To unify production and other technical activities, the North Eastern Marine, Parsons Marine and George Clark shipbuilding companies have become the Marine Division of the Richardsons Westgarth Group.

UK film in the States. Ilfords have shipped 12 cwt of their special G.5 nuclear photographic emulsion to America for recording particle activity at over 100,000 ft in the Caribbean atmosphere.

Fuel elements. Westinghouse is expanding its nuclear core manufacturing laboratories to provide additional development

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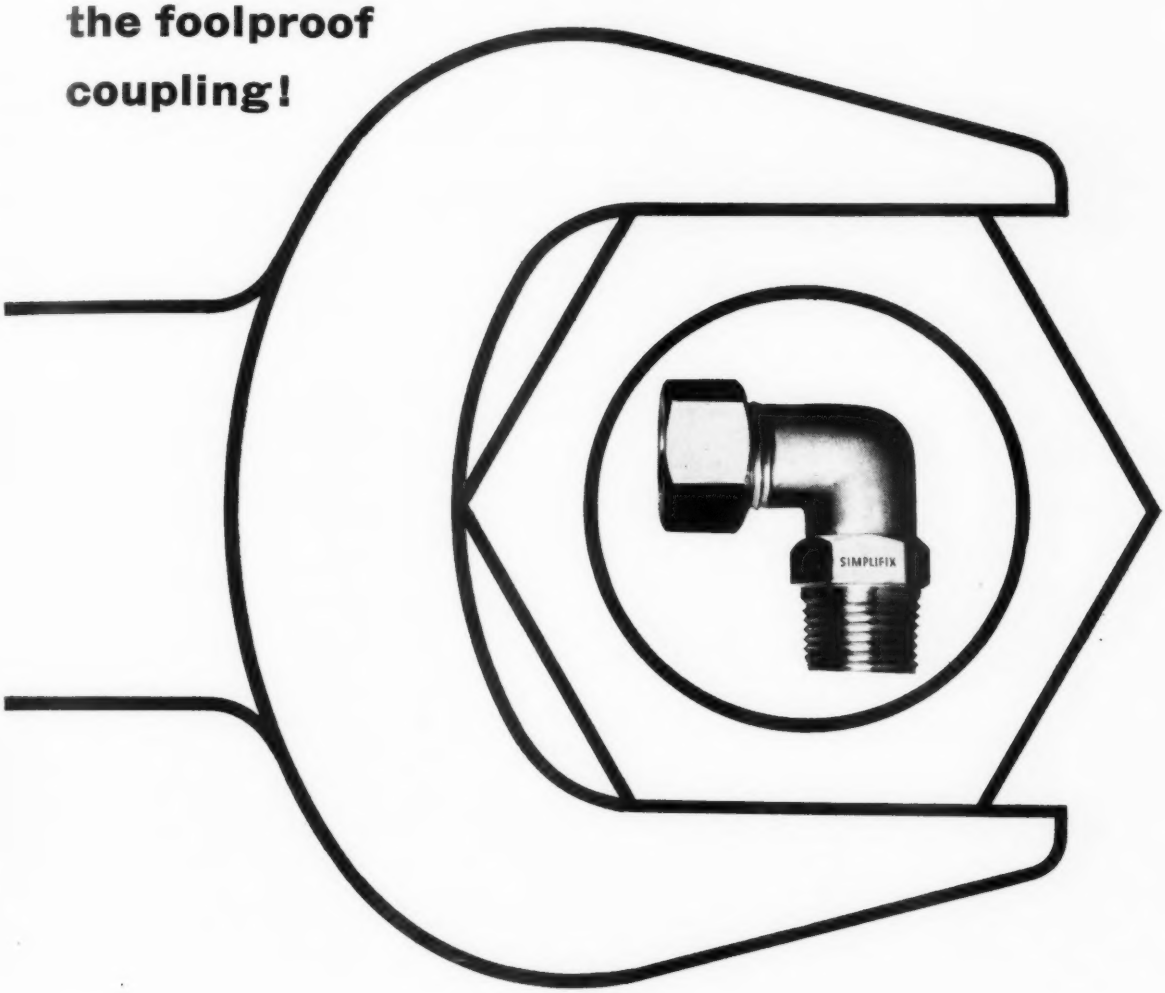

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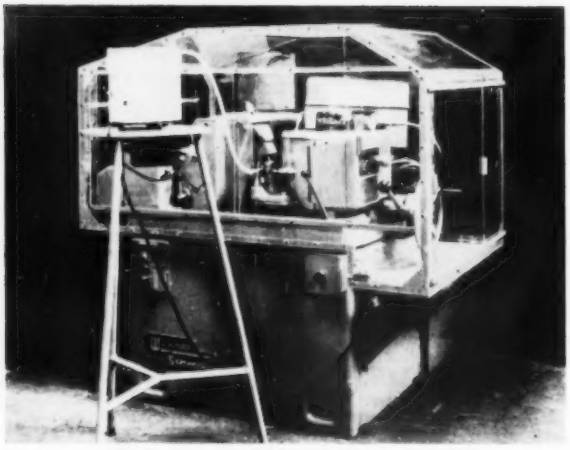


NEW APPLICATIONS
Using a vibrating hopper, uranium slugs are fed into a Scrivener centreless grinder which has an output of several thousand pieces per hour. To meet the requirements for the control of toxic dust this standard machine is completely shrouded

and production facilities for fuel elements and core components. An additional facility is nearing completion to house a newly formed group—the Nuclear Components Development Laboratory.

More processing. The Kerr-McGee Industries Inc have received a contract from the AEC for uranium concentrate for their 300-ton-a-day mill at Shiprock. The contract, operating from November 1 last, will run to June 30, 1965.

Nuclear training. The AEC has accepted applications for 237 fellowships for the 1960–61 academic year in three programmes which offer graduate training in specialized fields relating to nuclear energy.

LOOKING AHEAD

MONDAY 1 FEBRUARY
Industrial Separation of Isotopes K. D. B. Johnson, MA, BSc, Society of Chemical Industry 6.30 at 14 Belgrave Sq., London, SW1

TUESDAY 2 FEBRUARY
The Potentialities of Nuclear Power P. T. Fletcher, CBE, BSc, MICE, MIMechE, MIEE, Deputy Managing Director, Development & Engineering Group, UKAEA, the Institution of Plant Engineers 7.00 at the Royal Society of Arts, John Adam St., London, WC2
Industrial Metering the Institution of Plant Engineers 7.30 at the White Lion Hotel, Church St., Peterborough

WEDNESDAY 3 FEBRUARY
The exchange of Deuterium between Hydrogen and liquid Ammonia P. J. Bourke and C. J. Lee. The Institution of Chemical Engineers 6.30 at the Midland Hotel, Birmingham

THURSDAY 4 FEBRUARY
Polyurethane Foams; their contribution to Heat Insulation J. M. Buist, BSc, AMIF, and R. Hurd, BSc, the Institution of Refrigeration 5.30 at the Institute of Marine Engineers, The Memorial Bldg., 76 Mark Lane, London, EC3

FRIDAY 5 FEBRUARY
The Future of Chemicals from Petroleum The Levinstein Memorial Lecture, L. H. Williams, the Society of Chemical Industry 6.30 at the Large Chemistry Theatre, The University, Oxford Rd., Manchester

SUNDAY 7—SATURDAY 20 FEBRUARY
Digital Computer Course. Directed by Dr. Andrew Booth the course will be held in London by the British Council

TUESDAY 9 FEBRUARY
Problems in Chemical Engineering Maintenance J. C. Veale, MEng.AMICE, MIMechE, the Institution of Plant Engineers 7.15 at the Engineers' Club, Albert Sq., Manchester

WEDNESDAY 10 FEBRUARY
Uses of Aluminium in Engineering the Institution of Plant Engineers 7.30 at Taypark Hotel, West Ferry, Dundee
Planned Maintenance Preventive Schemes T. H. Voss, the Instution of Plant Engineers 7.15 at the Grand Hotel, Broad St., Bristol

WEDNESDAY 10—THURSDAY 11 FEBRUARY
Gas-cooled Reactor Symposium. Delaware Valley Section of the American Nuclear Society at Philadelphia, Pennsylvania, USA

WEDNESDAY 10 FEBRUARY
Uses of New Metals Prof. Ball. Women's Engineering Society 7.00 at Hope House, 45 Great Peter St., Westminster, London, SW1

THURSDAY 11 FEBRUARY
Measurement, Automatic Control and Data Reduction as applied to a Cyclic Plant A. H. Doveton, AMIEE and K. C. W. Pedder The Society of Instrument Technology 7.00 at Manson House, 26 Portland Pl., London, W1
Selection of Electric Motors for Industrial Purposes H. C. Ruffle The Institution of Plant Engineers 7.00 at Roadway House, Oxford St., Newcastle-upon-Tyne
Electronics J. Siddon The Institution of Plant Engineers 7.30 at the Station Hotel, Chesterfield

THURSDAY 18 FEBRUARY
Some Experiences with Chemical Engineering Plant J. C. Veale, MEng, AMICE, MIMechE, AMIMinE, MInstF, The Institution of Plant Engineers 7.30 at the Castle Hotel, Blackburn

MONDAY 22 FEBRUARY
Modern Welding Methods R. T. Andrews The Institution of Plant Engineers 7.30 at the Hotel Leofric, Coventry

MONDAY 22—FRIDAY 26 FEBRUARY
First Engineering Materials and Design Exhibition at Earls Court, London, SW5

TUESDAY 23 FEBRUARY
Backscatter Method of Wall Thickness Measurement D. F. White, BSc, ARCS, AInstP and L. E. Taylor, ABritIRE, and,
Ultrasonic Resonance Method of Wall Thickness Measurement M. U. James, AMIEE, The Society of Instrument Technology 7.00 at Manson House, 26 Portland Place, London, W1

LOOKING FURTHER AHEAD

MARCH 2
The Role of Formal Education and Training in Nuclear Power Developments (Discussion) The Institution of Mechanical Engineers 6.00 at 1 Birdcage Walk, Westminster, London, SW1

MARCH 9
Recent developments in heat transfer O. A. Saunders. The Institution of Chemical Engineers 7.00 at the Houldsworth School of Applied Science, University of Leeds, Leeds, 2

MARCH 14–25
Course on Sanitary Engineering Aspects of Nuclear Energy Robert A. Taft, Sanitary Engineering Centre at Cincinnati, Ohio, USA

MARCH 16
The Simulation of a Large Chemical Plant on an Electronic Analogue Computer A. H. Doveton, AMIEE and K. C. W. Pedder The Society of Instrument Technology 7.00 at Manson House, 26 Portland Pl., London, W1

MARCH 17
Prospecting for Radioactive Minerals F. H. Hale, AMBritIRE, the Society of Instrument Technology 7.15 at Nottingham and District Technical College, Burton St, Nottingham

MARCH 21–22
The Computer in Production an informal discussion and visits to computer centres. Applications to The Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, SW1

MARCH 29–31
Symposium on chemical process hazards with special reference to plant design, the North Western Branch of the Institution of Chemical Engineers. Details to be announced later

MARCH 29—APRIL 1
Symposium on Fatigue of Welded Structures The British Welding Research Association and the Engineering Department, Cambridge University. Further details the BWRA, Abington Hall, Abington, Cambs

APRIL 6–9
International Mineral Processing Congress and Exhibition at Church House, Westminster, London, SW1

APRIL 15
Physics of the Nucleus and Radioactivity Measurement Technique (15 week course) University of Innsbruck. Applications to Leopold-Franzens-Universität, Innrain 52, Innsbruck, Austria
Nuclear Physics (12 week course) Brunswick Technical University. Applications to Technische Hochschule Braunschweig, Pockelstrasse 4, Braunschweig, Germany

MAY 3–13
Mechanical Handling Convention and Exhibition at Earls Court, London, SW5

MAY 5
Direct Conversion—Its Physics and Applications Donald H. Loughridge of GM Research Laboratories at Northwestern University, Evanston, Illinois, USA

JUNE 13–15
International Powder Metallurgy Conference. Metal Powder Industries Federation, American Institute of Mining Metallurgy & Petroleum Engineers at New York, USA

JULY (*Date to be announced later*)
Third International Conference on Medical Electronics to be held jointly in London by the International Federation for Medical Electronics & The Institution of Electrical Engineers

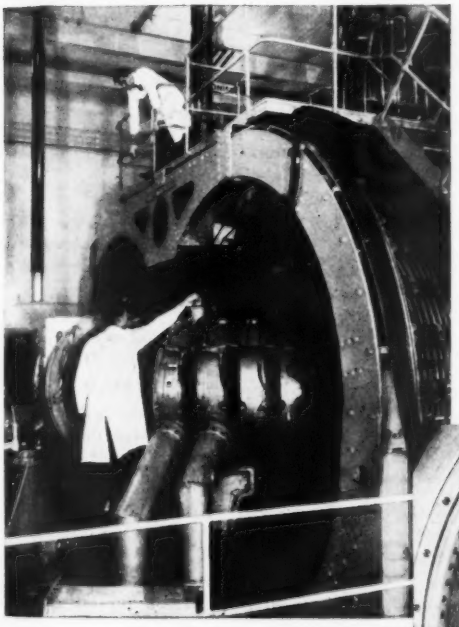
JULY 21–27
Third International Conference and Exhibition on Medical Electronics. Held jointly by the International Federation for Medical Electronics and The Institution of Electrical Engineers at the Empire Hall, Olympia, London

MAY 19—JUNE 4 1961
British Trade Fair and Exhibition at the Sokolniki Park of Culture and Rest, Moscow, USSR

TEDDINGTON BELLOWS
and Nuclear Power
HARWELL PAYS A TRIBUTE

Harwell top research scientists have freely acknowledged * that recent improvements in the operational efficiency of Zeta owe much to the introduction of a corrugated stainless steel liner inside the aluminium 'torus'. Having decided to use such a liner, they turned to Teddington engineers who, out of their experience in adapting their bellows expansion joints to various demands in a wide field of industry, produced exactly what was required for satisfactory running over long periods.

* *In a paper read before the I.E.E. on 29/30 April 1959 by Mr. J. T. D. Mitchell of the U.K.A.E.A., Harwell*



In Zeta, experiments towards controlling fusion have resulted in gas temperatures of several million degrees centigrade being achieved for millisecond periods. View showing the torus.

This stainless steel liner has improved operational characteristics and requires less maintainance than the original aluminium liner system. Here is part of the twelve welded sections of Teddington stainless steel bellows tube of wall thickness 0·017"; it has 2½ convolutions per inch of a depth of 0·75". The bellows is 38 inch bore and the whole toroidal bellows assembly has an axial length of 37 feet and an electrical resistance of 0·02 ohms.

SEND FOR HANDBOOK R. 23

Illustrated descriptions are given of the many and varied problems that Teddington Bellows Expansion Joints can overcome. If you did not secure your copy at the Engineering Exhibition, please write for one.

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NAMES IN THE NEWS

Some senior executives of Union Carbide Limited have been moving around. **Mr. L. E. Whitmore** has become director and general manager of the Polyethylene Division; **Mr. J. F. Widman,** previously director of marketing (chemicals) has become director and general manager of the Chemicals Division; and **Mr. R. Wilson** has been appointed director and general manager of the Alloys Division.

R. E. BURNETT moves up in Marconi Instruments

Mr. R. E. Burnett, MA(Oxon), AMIEE, AInstP, general manager of Marconi Instruments Ltd., has been elected to their board and appointed managing director of the company.

Mr. K. R. Simmonds, BSc(Eng), AMIEE, has been appointed general manager of the International Rectifier Co. (Gt. Britain) Ltd.

Mr. Bryan Harris, a graduate in metallurgy from the University of Birmingham, has been appointed to a TI Research Fellowship for work in the physics and chemistry of solids at the Cavendish Laboratory, Cambridge.

Three Vitro executives have been promoted to vice presidencies in the new Vitro Chemical Company; **Mr. Richard C. Cole,** now in charge of manufacturing, **Mr. Paul R. Kruesi,** to look after research and development, and **Mr. Malcolm H. McAllister** who will also continue being president of Berkshire Chemicals Inc.

Dr. VAN RENNES now with United Research

Coming from the Research Laboratories Division of Bendix Aviation Corporation, where he was supervisor of the Nuclear Technology Group, **Dr. A. B. Van Rennes** has taken over as vice-president of the Technical Division of United Research Incorporated. During the past eight years, Dr. Van Rennes has been consultant to various US Government and industrial groups on nuclear reactor kinetics, control and instrumentation.

J. F. SCHUMAR will lead J. J. Hopkins metals research

After acting as consultant to General Atomic's John Jay Hopkins Laboratory for the past four years, **Mr. James F. Schumar** has been appointed Chairman of the Metallurgy Department of the laboratory. Previously he was at the Argonne National Laboratory where he supervised the development of fabrication techniques of noble metals leading to the production of fuel elements for the STR, EBWR, EBR and the Savannah River reactors.

Mr. P. T. Williams has been appointed Director of Navy Contracts in succession to **Mr. B. Pool, CB, CBE,** who has held the post since 1948 and is now retiring.

Before becoming director, Mr. Williams was Head of General Finance, Branch 1, at the Admiralty.

Following the reorganization within the Head Wrightson Group of Companies, **Mr. G. P. Davidson** has been appointed Managing Director of Head Wrightson Processes Ltd. The retiring managing director, **Dr. R. C. Fisher** will continue to act as adviser to the board on nuclear research reactors and other nuclear projects.

J. BURKETT from Hawker Siddeley's to NUCLEAR POWER

Mr. Jack Burkett, FLA, has moved from Hawker Siddeley's to join the staff of NUCLEAR POWER as the Assistant Editor. He has been in the atomic energy field for a number of years, having been in charge of Information Services both at Hawker Siddeley Nuclear Power Co. Ltd. and Rolls-Royce Ltd. Previously he was in Government service in Civil Aviation and with the Home Office.

English Electric Valve Co. Ltd. has elected **Mr. A. J. Young,** BSc(Eng), MIEE, to the Board and appointed him managing director.

The leader of the British delegation to the High Authority of the Coal and Steel Community, **Mr. A. H. Tandy,** has been appointed the UK representative to the European Economic Community; he is already the British representative to Euratom.

CATALOGUES AND BULLETINS

Export information. Of interest to companies with large export interests is 'A guide to the development and export financing bodies.' This book, originally, produced by English Electric and now published by BEAMA (price 3s. 6d.) contains concise information on export financing bodies and export insuring schemes, either proposed or in operation.
Tick **No 255** on reply card

Liquid storage. Two new leaflets from Markland Scowcroft describes a wide range of cylindrical and rectangular tanks produced by them. Non-standard tanks up to 10,000 gallons capacity can be fabricated and prepared for any type of lining.
Tick **No 256** on reply card

Couplings. Leaflet from Allen Harrison & Co. gives sizes and other details of Kwik Joint couplings for use with water, oil, petrol, steam, gas, compressed air and chemicals.
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New heat transfer medium. Thermex, a pale yellow liquid consisting of the eutectic mixture of diphenyl oxide and diphenyl, has now been introduced for liquid-phase and vapour-phase heating and cooling for a variety of industrial processes.
Tick **No 258** on reply card

News around the world. Interesting pieces of information from many parts of the world have been included in the Autumn number of the CAC magazine which confirm the increasing use of efficient thermal insulation.
Tick **No 259** on reply card

Filter applications. Lavishly produced brochure from Auto-Klean Strainers describes their comprehensive range of filters and illustrates some of their more unusual applications for nuclear engineering, boilers, chemicals etc.
Tick **No 260** on reply card

Helping the draughtsman. A new folder issued by Keith Blackman should be in the possession of every designer and draughtsman whose equipment include fans, blowers or exhausters. It clearly indicates the full range of standard input and discharge positions.
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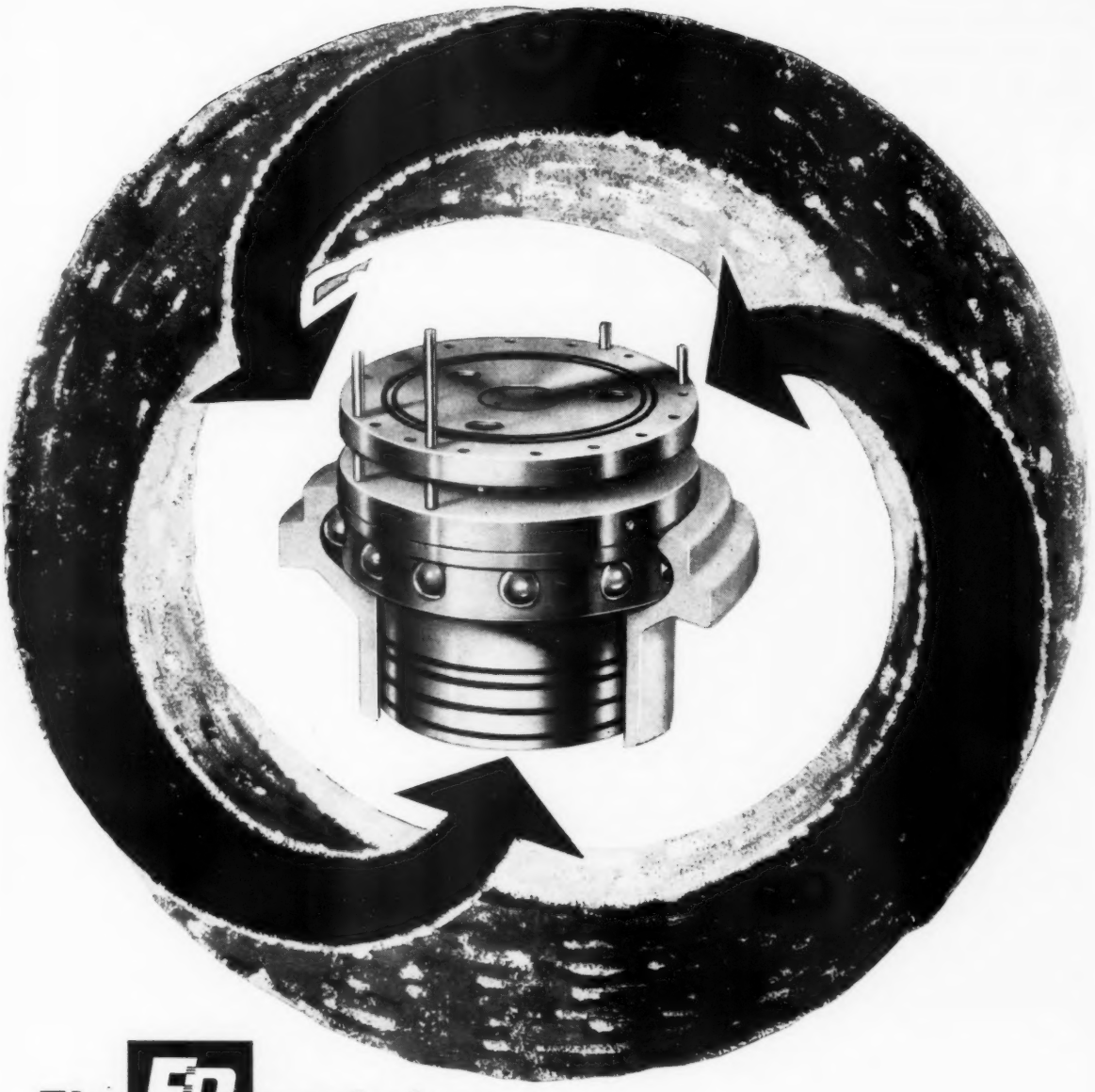

The FR seal plug

The FR Standpipe Seal Plug, the design of which is backed by several years of testing and research and covered by world patents, has been adopted by every major nuclear energy design group. Its main advantages are as follows:

1 Suitability for any reactor fluid and any reactor temperature or pressure.

2 Top, bottom or side mounting.

3 Can be mounted in any radial position.

4 Fitted or removed simply by lowering or lifting and hence this operation is extremely rapid.

5 Can be provided with clearbore holes for flux scanning, control rod drives, etc.

6 A pressure lock prevents plug being removed until pressure is equalised above and below (e.g. reactor blown down or pile-cap machine coupled and pressurised.)

7 A mechanical lock prevents plug being lifted until grab is correctly secured to plug lifting attachment.

The Company would be pleased to draw up specifications of Seal Plugs to meet any given problems.

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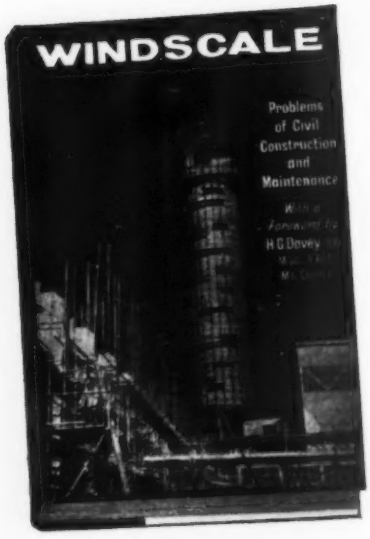
The first full and factual account of the Windscale project—

WINDSCALE

Problems of Civil Construction and Maintenance

by Stuart Sinclair, M.I.C.W.



With a Foreword by H. G. Davey, O.B.E., M.Sc., F.R.I.C., M.I.Chem.E.

This book is written, with the full approval of the United Kingdom Atomic Energy Authority, by a Clerk of Works at Windscale. It is addressed mainly to civil engineers and construction personnel, as well as to those engaged in the expanding programme of nuclear power stations. However, following the mishap which occurred in Pile Number 1 in October, 1957, the eyes of many people were focussed on the Factory; and the book provides an account of how the factory took shape and gives some of the maintenance problems connected with this operation.

CONTENTS:

Choice of a Site · Site Clearance · First Stages of Construction · Construction of the Pile Chimneys · Construction of the Effluent Pipelines · Remedial Work to the Biological Shields · Operation · Blowhard Day-to-Day Maintenance Problems · Index · Half-tone and Line illustrations.

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NEWNES

Book Reviews

Aqueous processing

Progress in Nuclear Energy, Series III, Volume 2: Process Chemistry 1959: Pergamon Press 579 pp Price £5 10s.

The first volume in this series made an important contribution to the literature of nuclear process chemistry and this second volume brings the subject up to date with more valuable and exhaustive survey papers. In general they are chosen to illustrate processes of industrial importance at the present time and so this volume deals largely with aqueous processes.

The first three chapters discuss the recovery of uranium and thorium from ores and the extraction of radioactive by-products such as thorium-230 (ionium), protactinium, and radium etc. The eight papers of chapter 4 are primarily devoted to a description of methods for the conversion of purified raw materials to a form suitable for metal fabrication. Whilst the processes are fairly well known, there are descriptions of new techniques. Thus the fluidized bed process for production of uranium tetrafluoride is discussed by Jonke and Levitz and another paper by Brater and Smiley describes the direct reduction of uranium hexafluoride by hydrogen.

Ullman briefly discusses in chapter 5 the various factors which make up the cost of processing reactor fuels. Whilst this is a useful contribution to a subject which so far has received less attention than it deserves, it is a pity that the editors had not ensured a more exhaustive treatment.

Chapters 6 and 7 are devoted to a consideration of solvent extraction and ion exchange processes, respectively. The former is probably the most important chapter in the book, as solvent extraction forms the basis of nearly all present-day large-scale separation processes. Particularly appropriate are the sections by Burger and by Rigg and Wild on the effects of radiation on solvents. Other techniques which are not at present used in commercial processing are described in chapter 9.

In chapter 10 on waste disposal Saddington discusses Windscale practice for high-level radioactive saltless wastes, whilst Sammon reviews solutions to the problem of low-level wastes. Roger and Fineman survey present American methods of handling waste. The production of kilo-curie sources of caesium-137 at Windscale and methods for the separation of neptunium-137 are covered in the final chapter.

Whilst this book represents a valuable addition to the literature of nuclear process chemistry and, as such, is strongly recommended, there are grounds for some criticism of the choice of subject matter. Several papers tend to contain a mass of undigested facts without a sufficient attempt to provide a critical assessment. There are not enough descriptions of process equipment, with the exception of the good paper by Jamrack, Logsdail and Short on laboratory mixer-settlers. There is a need for good papers on the design of such equipment and perhaps the role played by special instruments in current plant. There is also a need for a review of the subject of criticality and its bearing on the design and operation of plant for the processing of fissionable materials. It is to be hoped that these subjects will be discussed in volume 3, but without producing a book any longer than this one.

G. R. Hall

Three more Geneva volumes

Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy Her Majesty's Stationery Office, 1958

Vol 6 Basic metallurgy and fabrication of fuels 720 pp £6 9s

Vol 7 Reactor technology 844 pp £7

Vol 9 Nuclear power plants Part 2 538 pp £6 5s

The remaining two of the three volumes dealing with reactor fuels, coolants and structural materials are now published. In volume 6 the scope of the section on basic metallurgy is very wide and covers the mechanical properties of uranium, plutonium and thorium as metal and alloys, behaviour and physical properties of alloys in various combinations, irradiation effects and corrosion behaviour. The latter sections deal primarily with fabrication of uranium fuels as metals, alloys, ceramics or oxide, and also with plutonium fuels.

The major part of the companion volume 7 is devoted to the behaviour of fluids in reactors. Hydraulic aspects are concerned with circulation of liquid fuels, both aqueous and metallic, and liquid sodium coolant. Thermal aspects include heat transfer to gaseous, liquid, and mixed coolants. The remaining papers deal with irradiation damage and Wigner release, b.s.d., and design of fuel handling equipment.

Completing the world-wide compendium of data on power reactors (volume 8 was reviewed last July), volume 9 deals mostly with concepts for future plants with conclusions drawn from existing experimental power reactors.

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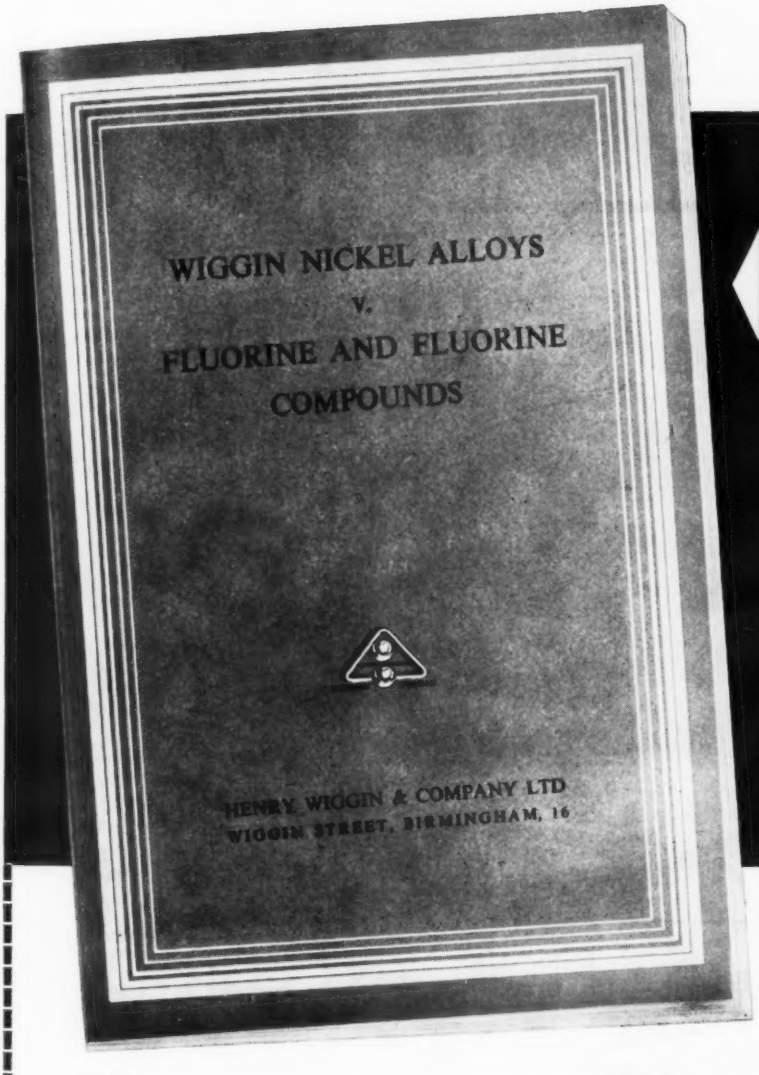

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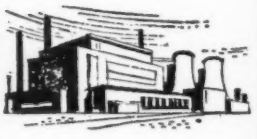

HINKLEY
C.E.G.B. NUCLEAR POWER STATION

At Hinkley Point, Newalls have been entrusted with the insulation of the reactors, steam raising units, gas ducting, integral piping, etc., under contract to Babcock and Wilcox Ltd.

CHAPELCROSS
U.K.A.E.A. NUCLEAR POWER STATION

Under contract to Babcock and Wilcox Ltd., Newalls are carrying out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping is being carried out under contract to C. A. Parsons and Co. Ltd.

BRADWELL
C.E.G.B. NUCLEAR POWER STATION

At Bradwell-on-Sea a further large contract for the thermal insulation of turbines, associated auxiliary equipment and piping (main and auxiliary turbine plants) has also been placed by C. A. Parsons and Co. Ltd. with Newalls.

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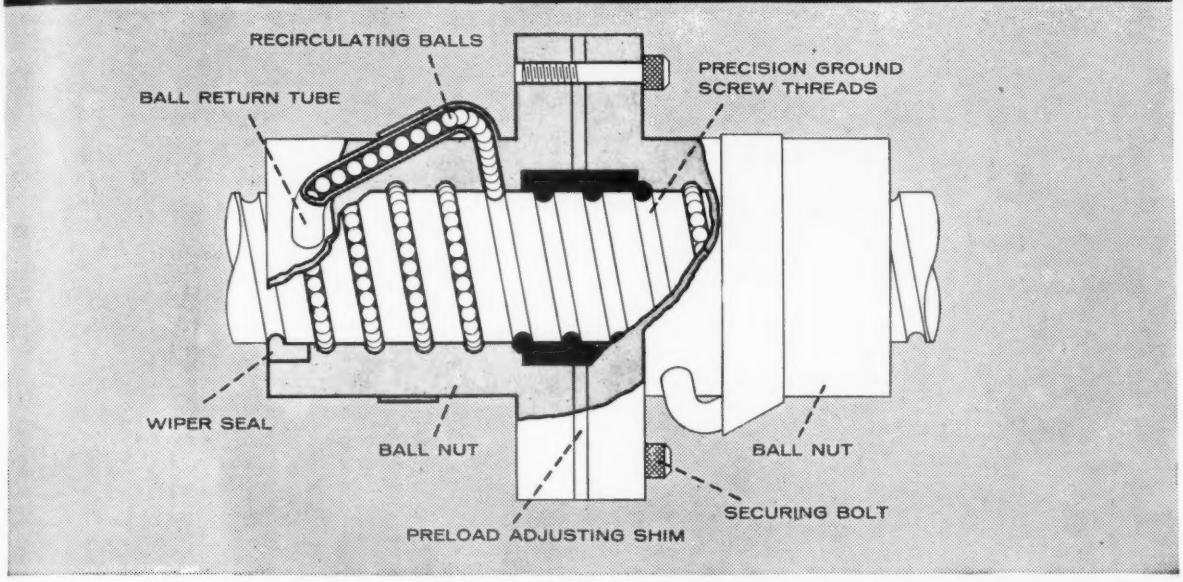

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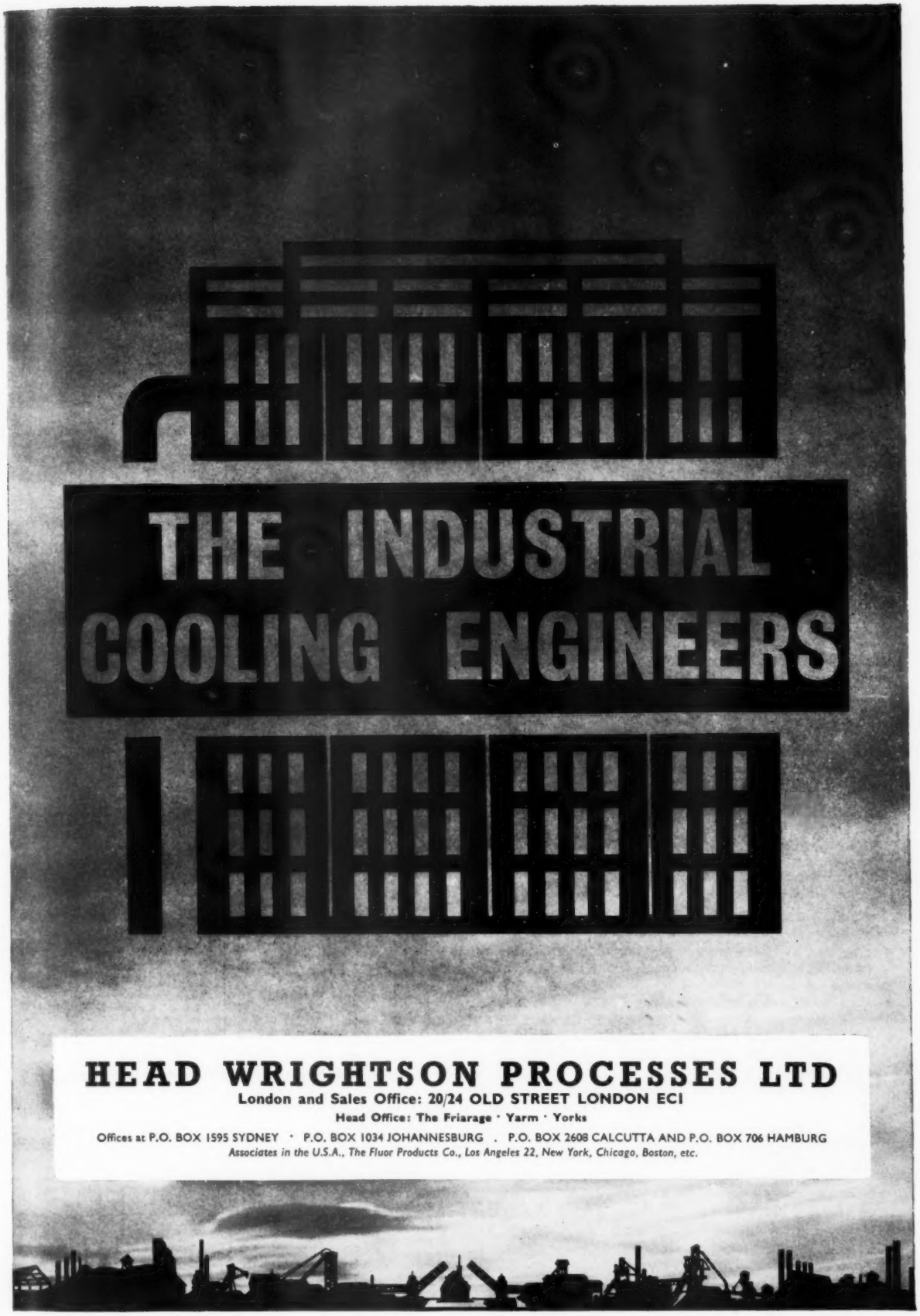

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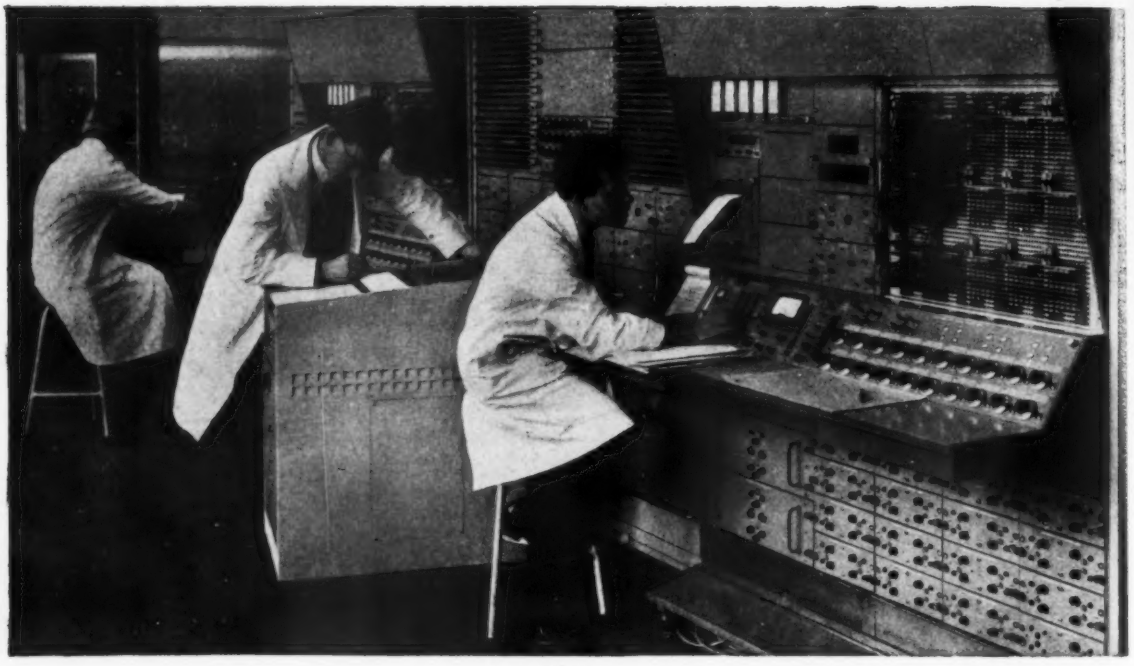


HARWELL CHOOSES PACE ANALOG COMPUTER

The above photo shows the Analog Computing System which was purchased by Harwell and recently installed at the U. K. A. E. R. E. Winfrith Heath Laboratory at Winfrith, Dorset, England. This System consists of two fully expanded PACE 231 R Computers, which are of great assistance to scientists of this world famous Research Center in their Nuclear Studies.

Important types of Nuclear Problems that can be solved by Analog Computers include the following : Neutron-Flux Distribution, Reactor Dynamic Analysis, Radioactive Fallout Predicting, Xenon Poisoning in Reactors, Reactors & Power Plant Simulation, Linear Proton Accelerator Design, and Diffusion Problems.

Among the outstanding advantages that PACE can offer Nuclear Clients are :

- ★ The *experience* and *research facilities* of Electronic Associates, world's leading producers of Analog Computers for over 8 years.
- ★ *High quality* and *reliability*, evidenced by .01 % linear and non-linear components - standard with PACE since 1954.
- ★ Ability to offer a *wide range* of linear and non-linear elements, together with all types of input and output equipment.
- ★ Built-in *automatic features* to ease programming and problem preparation, such as ADIOS (Automatic Digital Input-Output System), AERO (Automatic Read Out System), Automatic Problem Check, and new removable Modular Pre-Patch Panel.
- ★ E. A. I. sells over 300 systems each year, ranging in size from 10 to over 500 amplifiers, permitting it to maintain *high quality* at *economic cost* to clients. In the past two years 50 PACE Systems have been sold in Europe alone.

Some of the European Nuclear clients who have purchased PACE, in addition to Harwell, are :

FRANCE.
Commissariat à l'Energie Atomique, Saclay
Lab. de Physique Nucléaire Univ. de Paris
Cie Française Thomson Houston

GERMANY.
Brown Boveri
Telefunken
Kernreaktor
Technische Hochschule Darmstadt
Technische Hochschule Stuttgart
Deutsches Elektronen-Synchroton (DESY)

GREAT BRITAIN.
Central Electricity Generating Board
General Electric Co Ltd.
A.E.I. John Thompson Nuclear Co.
U.K. A.E.A. Industrial Group, Risley

HOLLAND.
Philips Research Labs
Reactor Centrum
K.E.M.A.

ITALY.
Agip Nucleare
Ca Generale di Elettricita
Costruzioni Elettroniche e Automatismi (C.E.A.)

SCANDINAVIA
ASEA, Sweden
Institutt for Atomenergi, Norway
Rekeriaktibolaget Nordtiernan, Sweden
Chr. Michelsens Institutt, Norway.
Atomenergi, Sweden

Skilled Application engineers from the E. A. I. European Computation Center in Brussels stand ready to assist European industries with their Computer Systems and Instrumentation problems.

DETAILS OF OUR COMPLETE LINE OF PACE COMPUTERS AND INSTRUMENTS WILL BE SENT UPON REQUEST.

EAI

ELECTRONIC ASSOCIATES LTD· Works and Head Office : Victoria Road - Burgess Hill - Sussex - England
Tel. 11.43.69. Telex : PACE BELGBRU.

European Computation Center and Continental Sales Office - 43, rue de la Science Brussels 4 - Belgium
Tel. Burgess Hill 26 36. Telex PACE BURGESSHL

PRODUCERS OF PACE ANALOG COMPUTERS
REGISTERED TRADEMARK

PAINTING CONTRACTORS

STRUCTURAL PAINTERS LTD

SAINT NICHOLAS BUILDINGS
NEWCASTLE ON TYNE

Also at

WALSALL · GLASGOW · MIDDLESBROUGH

Now engaged at

WINDSCALE · RUGELEY · KINCARDINE

WE WOULD WELCOME YOUR ENQUIRIES

The HINDLE H15
Fluon-Seated Leakproof Gate Valve

Illustrated below is a section of this unique valve. Fluon Seats ensure a positive seal on both downstream AND upstream faces

When closed removal of a bonnet bleed plug gives visible proof that the valve is NOT LEAKING

Made in Stainless Steel and Carbon Steel

Covered by British American French and Italian Patents

We will gladly demonstrate this Valve anywhere at any time

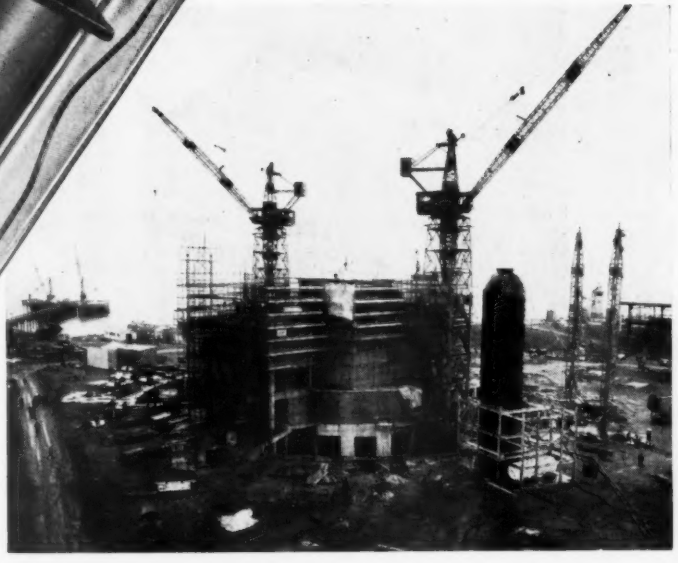
JOSHUA HINDLE & SONS LIMITED
Hindle House, Leeds 1. Phone Leeds 30567 (4 lines)
LONDON OFFICE:
157 Prince's Gardens, Acton W3. Phone ACOrn 2471

"PLUG-IN"
3000 TYPE RELAY

As supplied exclusively for

BERKELEY POWER STATION

A.I.D. A.R.B.
ADMIRALTY APPROVED
3000 & 600 TYPE RELAYS



WITH TRANSPARENT DUST COVER AND PLUG-IN BASE

SIZE OF BASE 2¾" × 1⅛" × ⅛"

NOW SUPPLIED AS FOLLOWS

- 6 Change-overs Light Duty
- 6 Makes or 6 Breaks Heavy Duty
- 2 Change-overs Heavy Duty and 2 Change-overs Light Duty

Transistorised to operate as low as 3 micro-amps
A.C. Operation for: 6v. 12v. 24v. 50v. 110v. and 250v. A.C.
• Double Wound Coils • P.T.F.E. Insulation
• Operate and Delay up to 5 Seconds

A.D.S. RELAYS LTD
89-97, ST. JOHN STREET, CLERKENWELL, E.C.1
Telephone: CLErkenwell 3393/4/5

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WESTON

MOVING COIL

RELAYS

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays. Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should, if possible, be accompanied by full particulars of both control and local circuits.

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

SANGAMO WESTON LIMITED
ENFIELD · MIDDLESEX
Tel: ENField 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield

Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 41151
Branches: London, CHAncery 4971 · Glasgow, Central 6208 · Manchester, Central 7904 Newcastle-upon-Tyne, Newcastle 26867 · Leeds, Leeds 30867 · Liverpool, Central 0230 Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 · Bristol, Bristol 21781 · Southampton, Southampton 23328.

SW/67

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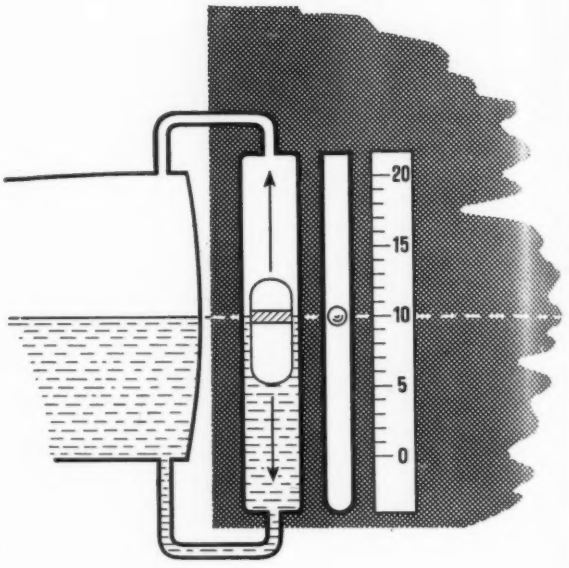
So Simple . . .



yet so safe!

All process liquid confined to metal housing, floating magnet, and hollow iron indicator ball: these are the elements of the Ekstrom Liquid Level Indicator, essential for the SAFE level indication of corrosive or toxic liquids or liquefied gases under pressure. A branch tube from the storage vessel carries a magnetic float. A separate glass indicator tube carries an indicator ball. Adjustable electric or pneumatic alarm switches are available.

This illustration shows a typical installation. An Ekstrom Level Gauge fitted to a tank containing liquid butane at the Luton works of Vauxhall Motors.

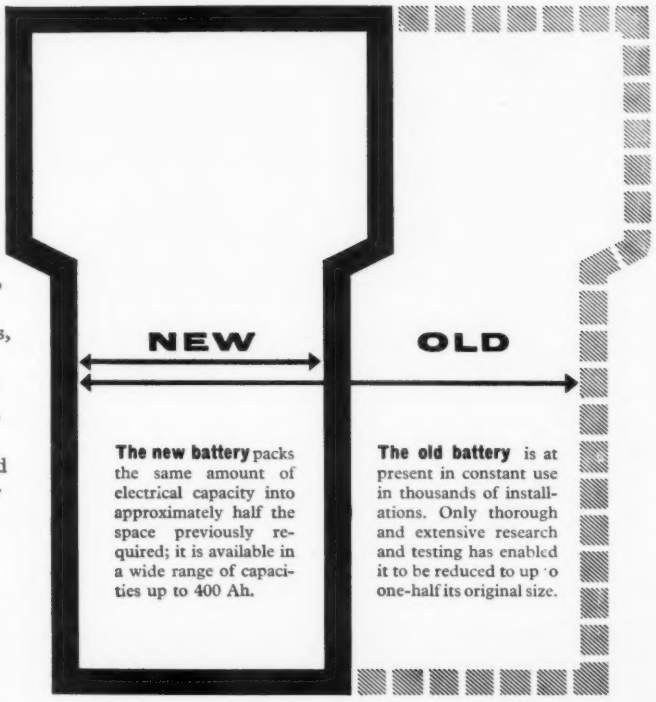
ROTAMETER
FLUID MEASUREMENT AND CONTROL
FLOW-DENSITY-LEVEL
ROTAMETER MANUFACTURING CO. LTD. Purley Way, Croydon, Surrey
Telephone : Croydon 3816

E14

BATTERY SPACE REDUCED BY HALF

WITH THE NEW TUDOR HIGH PERFORMANCE STATIONARY CELL

Savings of up to 50% in the space required for a stationary battery are made with the introduction of a new Tudor cell. A high performance sealed cell with Planté positive plates and pasted grid negative plates, separated by ribbed diaphragms of microporous Porvic, it is specially designed for trickle-charge operation.
It is therefore the ideal cell for all stand-by applications, including emergency lighting in hospitals, cinemas, theatres and public buildings of all kinds, and auxiliary duties in both nuclear and conventional power stations.
The design of the cell results in a lower internal resistance and therefore provides a very much improved high rate performance, making it eminently suitable for switch-operating duties where high rates of discharge are involved.
With the great reduction of space required, and the renowned reliability and long life of its predecessors, this new Tudor high performance cell marks a great step forward in stationary battery design.

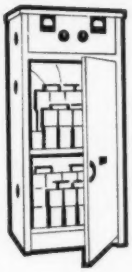


The new battery packs the same amount of electrical capacity into approximately half the space previously required; it is available in a wide range of capacities up to 400 Ah.

The old battery is at present in constant use in thousands of installations. Only thorough and extensive research and testing has enabled it to be reduced to up to one-half its original size.

THE IMPROVED SAFETYLYTE EMERGENCY LIGHTING EQUIPMENT

Tudor Safetylyte equipments are now being fitted with the new stationary cell. Charge and control cubicles are of improved design – the larger equipments being of folded sheet steel, and the smaller specially constructed for wall-mounting, employing automatic mercury relay in place of a contactor.



THE NEW SWITCH-TRIPPING EQUIPMENT

Tudor switch-tripping units will in future be fitted with the new cell. The cubicles have also been redesigned, and are available in folded sheet steel or wooden cabinet construction. The charger can now be used for both trickle and quick charging.

T 173A

Tudor TUDOR BATTERIES

THE D.P. BATTERY CO. LTD, MAKERS OF KATHANODE AND TUDOR BATTERIES, BAKEWELL, DERBYSHIRE. TEL BAKEWELL 581-5

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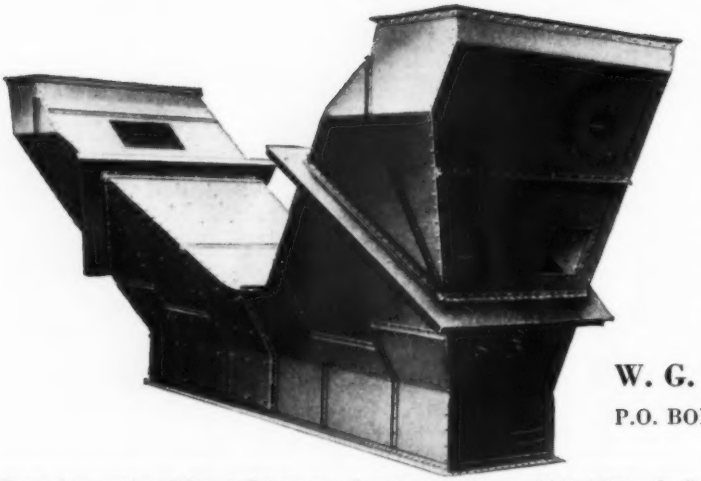
Fabricated Platework to your specification



We specialise in welded or riveted fabrications in Mild Steel, Stainless Steel and Aluminium Alloys and pride ourselves on the attention paid to constructional details which ensure trouble-free service for the finished product.

A typical example of our craftsmanship is the fabrication of Ducts of rectangular design for Power Stations or Boiler Houses. They are accurately fabricated to suit your requirements.

Our "FABRICATED PLATEWORK" Brochure fully describes our Service and is available on application.

W. G. ALLEN & SONS (TIPTON) LTD.

P.O. BOX 4 · TIPTON · STAFFS

Tel: TIPTON 1266

Typical examples of Allen's Fabrication Service: *Low Pressure Welded Piping for Exhaust Steam, Gases, Water, etc. Pipes and Ducts for Super Power Station Boiler Plant; Hoppers; Casings; Tanks; Flat Platework; Manipulated Platework of all kinds; Bed Plates and Frames for Machines, etc*

NEW K FROM K.D.G.

'K' SERIES
PRESSURE GAUGES

Brand new and made to last, is this New Long Life Pressure Gauge by K.D.G. It is guaranteed not to have an error greater than ± 1% of the full scale deflection between 10 and 90% of maximum scale reading, the remainder of the scale being within ± 1½%. Conforming to British Standard Specifications 1780: 1951.

- ★ Stainless Steel Mechanism
- ★ Heavy duty BOURDON TUBE design
- ★ Easy to read dial layout
- ★ Safety Blow-out Discs
- ★ **Extensive Life . . . at a competitive Price**

CRAWLEY KDG LONDON

Full details and specifications of the complete K.D.G. range are readily available from:

K.D.G. INSTRUMENTS LTD.,

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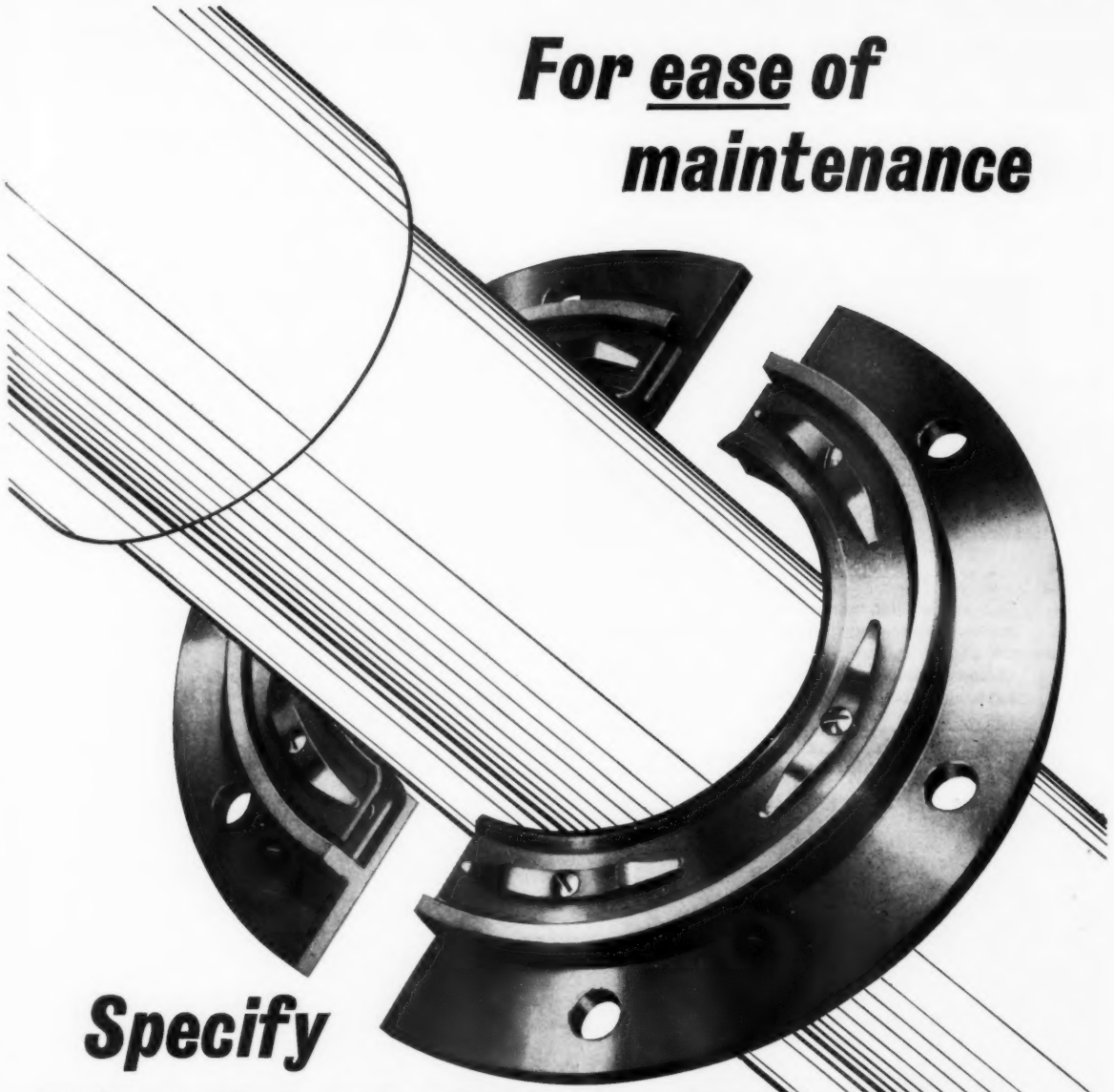
London Showrooms, Service and Sales: 100 Fleet Street, E.C.4 · Tel.: FLEet 5354/5

For ease of maintenance



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WESTON

SPLIT SEALS

CHARLES WESTON & CO. LTD. Irwell Bank Works · Douglas Green · Pendleton · Salford 6

Telephone: Pendleton 2857-8-9; Telex 66-255; Birmingham Erdington 5459; London Holborn 0414; Telex 2-2682

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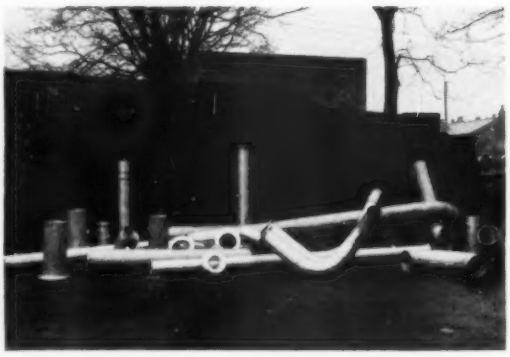
Specialists in Aluminium Alloy Plate and Structural Fabrications of all descriptions



One of the first users of the Argon Arc welding process in the country, we again lead in the installation of the Sigmette Fine Wire welding equipment which opens a new field in the welding of Aluminium and its alloys, Non-Ferrous metals and Stainless Steels

Heat Exchangers
Pressure Vessels
Structural Aluminium of all descriptions
Smooth bore pipes and fittings up to 24" diameter

Your enquiries would receive our immediate attention

Illustrated is an 8" and 12" Bore Pipe Installation fabricated for the Ministry of Supply

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HEATING UNIT for a HIGH TEMPERATURE VACUUM FURNACE with a Tungsten Rod Heating Element mounted on the Inner Molybdenum Radiation Screen

For temperatures up to 1,700° C.

MUREX LIMITED *(Powder Metallurgy Division)*
RAINHAM · ESSEX · *Telephone: Rainham, Essex 3322*
Telex: 28632 Telegrams: Murex, Rainham-Dagenham Telex
London Office: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1 *EUSton 8265*

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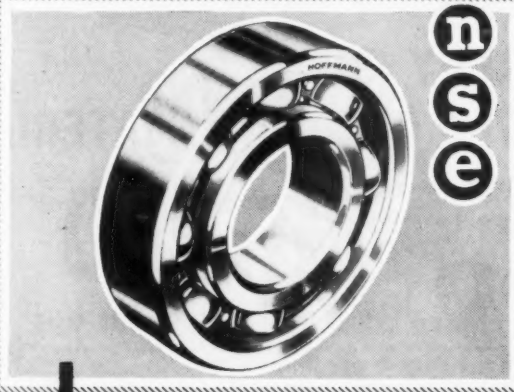
HOFFMANN

instant response

at the touch of a button

● Designed to aid the smooth transmission of power: to reduce friction to a minimum: to enable movement at "touch of a button response"—HOFFMANN Ball and Roller Bearings characterised by their dependability . . .
Dependability under light or heavy loads; at low or high speeds: in extremes of temperatures: in dirt, dust, and fumes . . .
Dependability that makes lubrication and maintenance so little as to be negligible in time and cost . . .
Dependability that springs from over 60 years of experience in designing and manufacturing ball and roller bearings . . .
And this experience is available to all users of bearings. Where there is a problem Hoffmann will be pleased to help.



ball and roller

Hoffmann Bearings

THE HOFFMANN MANUFACTURING CO. LTD.
CHELMSFORD, ESSEX *Telephone : 3151 (seven lines)*

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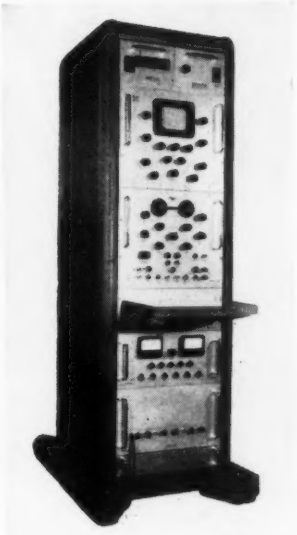
MARSHALL



PULSE HEIGHT ANALYSER
TYPE H.S.100

★ Torsional delay line data storage with computer reliability
★ Resolution constant or proportional to amplitude
★ Background subtraction
★ Analysis of pulses of either sign from 1 mV to 50 V
★ Binary and decimal storage
★ Both digital and analogue display
★ Storage capacity 2400 digits
★ High stability and linearity
★ Built-in precision test pulse generator
★ Analogue readout and automatic printout using either adding machine or electric typewriter
★ Total count scaler and accurate live time integrator both of which are available for use as separate units

MARSHALL
TWIN-CHANNEL PULSE GENERATOR MODEL T·P·G·100

Designed as a universal instrument for the development and general testing of electronic equipment. Extreme flexibility in use is achieved by virtue of the complete independence of the two channels apart from a common repetition frequency. The output pulses are fast-rising, of clean waveform, and at low impedance level.
In addition to the facilities normally offered in a pulse generator, precise measurements of the resolution time of coincidence circuits, triggering characteristics of discriminators, and the overload performance of pulse amplifiers are readily made.
A pre-pulse is provided for the purpose of triggering auxiliary apparatus.
The "A" and "B" channel output pulses are independently variable in amplitude, duration, risetime, delay relative to the pre-pulse and polarity.
Pulses from the two channels may be additively mixed if desired so that they appear at a single terminal.

FOR COMPLETE DATA WRITE TO:

MARSHALL OF CAMBRIDGE ELECTRONICS LIMITED
THE AERODROME, CAMBRIDGE, ENGLAND

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"B-W" *Flowline Heaters...*

The illustration shows a recent batch of 'B-W' 65 KW electrically-heated units with their associated Control Panels. These Gas and Air Flowline Heaters are representative of the wide range of Barlow-Whitney custom-built process equipment supplied to the Nuclear and Chemical industries and heated by electricity, gas or other fuels.

WRITE FOR FURTHER DETAILS QUOTING REFERENCE C260

PROCESS HEATING *Barlow-Whitney*

BARLOW-WHITNEY LTD., 2 DORSET SQUARE, LONDON, N.W.I. Tel: AMBassador 5485 Works: LONDON & BLETCHLEY

BMJ

WE CAN CARRY OUT HYDRAULIC PRESSURE TESTS ON YOUR MATERIAL

(to destruction if necessary)

AT PRESSURES UP TO

100,000 lbs P.S.I.

(Yes, we mean One Hundred Thousand Pounds per Square Inch.)

CERTIFIED TESTS UNDER LABORATORY CONDITIONS

Charles S. Madan & Co. Ltd.

VORTEX WORKS, ATLANTIC ST., ALTRINCHAM

Tele: ALTRINCHAM 2702 (3 lines) Grams: VORTEX ALTRINCHAM (Telex)
TELEX 66-105 A/B ATLANTIC ALCH'M

CM18

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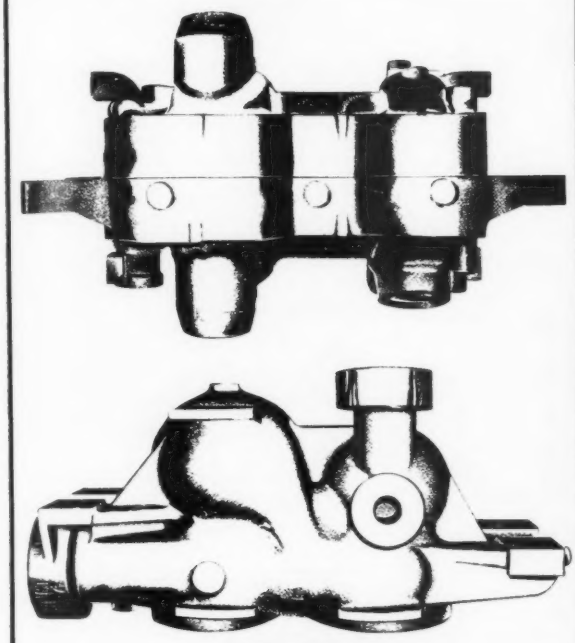

ATLAS

STEEL CASTINGS

FOR INTERNAL PRESSURE WORK

Turbine Casings, Steam Chests, Valves, etc., in carbon and alloy steels up to 15 tons weight and to any specification on ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

THE ATLAS STEEL FOUNDRY & ENGINEERING CO. LTD.

Atlas Steel Works: Armadale, West Lothian, Scotland
Telegrams: "Atlas Armadale, West Lothian"
Telephone: 323 Armadale

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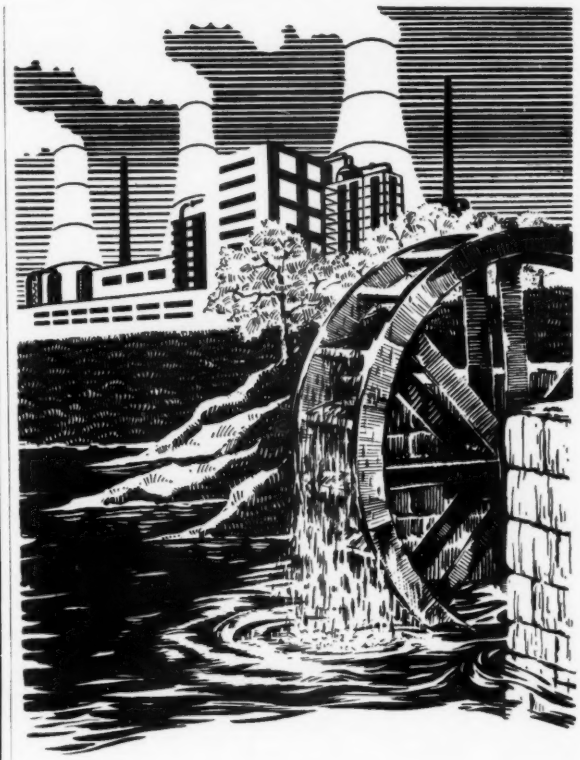

WATER

is still in the foreground...

However revolutionary the methods of producing power may become, water is still all-important; and the need to give complete and lasting internal protection to water tanks in modern plants remains paramount.

With a reputation consolidated over 30 years of successful use **BITOTES Solution and Enamel** prevents interior corrosion of all steel and concrete water containers and conduits. BITOTES cannot crack or peel and is tasteless and odourless when dry. It is fully approved for Fresh Water, Drinking Water, Demineralised Water, etc.

May we send you details

BITULAC LIMITED
(PAINTS DIVISION)

Collingwood Buildings, Newcastle upon Tyne, 1.
London Office: 189/190 Temple Chambers, Temple Avenue, London, E.C.4

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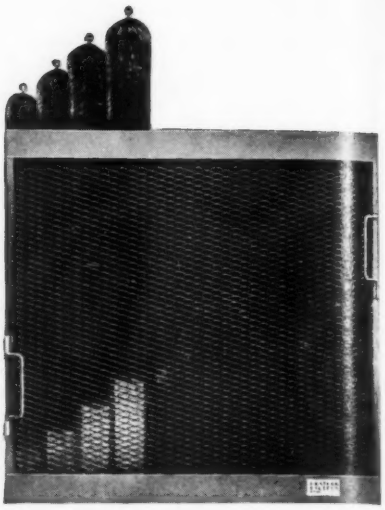
YOU DON'T NEED SPECIAL EQUIPMENT OR FLUIDS TO CLEAN THIS AIR FILTER!

Heather Multi-Brush Air Filters can be cleaned easily and thoroughly, without special equipment or fluids, and still retain the initial filtering efficiency. In fact, maximum efficiency and minimum maintenance is the correct way to sum up this unique, low-cost filter system.



A finely graded mesh of intermingling hair, specially selected to withstand the varying humidity and conditions of the dust-laden air, is used to trap impurities and dust particles from the incoming air stream. Periodically, the filter brushes can be cleaned simply by shaking or suction cleaning.

✻ ***Write NOW for leaflet H38, which gives full details.***

HEATHER FILTERS LIMITED

7 KENDALL PLACE . BAKER STREET . LONDON W.I HUNTER 1801

H,F4

for CATHODIC PROTECTION

or WELDING INSPECTION

call in MAPEL

MAPEL

METAL & PIPELINE ENDURANCE LTD.,

30 London Road, Woolmer Green, Herts.

Tel: Knebworth 3083 Grams: Metaldure, Knebworth

Other offices at London, Newcastle-upon-Tyne and Glasgow

WORLD-WIDE SERVICE

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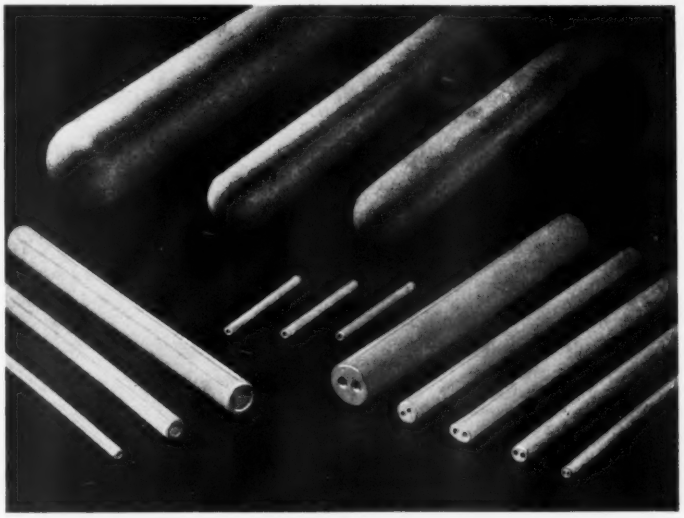
Where PYROMETRY prevails . . .

Higher Process temperatures demand accurate thermal control, and reliable pyrometer sheaths and thermocouple insulators are now an essential. Thermal aluminous porcelain, mullite and pure recrystallised alumina sheaths and insulators are used up to 1,500°C., 1,700°C. and 1,900°C. respectively, for temperature measurements in gas, oil and electrically heated furnaces, flues and pipelines.



● *Thermal Fused Alumina and Fused Magnesia powders and cements are also available.*

● *We also manufacture an extensive range of Vitreosil Laboratory Ware.*

TSL

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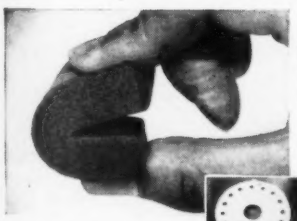
PRESCOLASTIK

REGD.

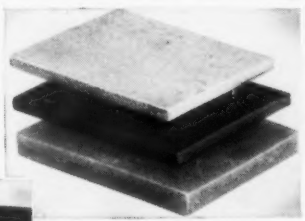
SILICONE RUBBERS

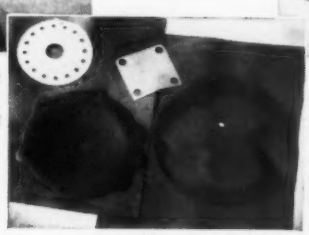
The most comprehensive range available



A. Prescolastik Expanded Silicone Rubber
Uses: Soft Gasketing, Vibration Damping, Seals, Pads and Dampers.

B. Prescolastik Silicone Rubber Sheet
Uses: Gaskets, Seals, Diaphragms, Washers, Etc.





C. Prescolastik Silicone Coated Fabrics
Uses: Diaphragms, Gaskets, Seals, Tapes, Ductings and Flexible Low Temperature Coverings.

TAKE ADVANTAGE of the technical resources and production facilities of the most modern silicone rubber plant in the United Kingdom.

Prescolastik silicone rubbers offer the widest available range of compounds to meet the most exacting conditions.

General Purpose Grades
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High Temperature Grades
H.T.P. Resistant Grades
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Specialists in precision rubber engineering

PRECISION RUBBERS LIMITED

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FILTERS ANYTHING THAT FLOWS

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Combined self-cleaning plate-type filter and paper filter giving both defined mesh and micronic protection for lubricating oil systems at flows up to 6,700 gallons per hour.

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Self-cleaning plate-type filters for all liquids handling flows up to 150,000 gallons per hour and providing positive defined mesh filtration with additional magnetic protection.

AUTO-KLEAN CIRCO
Self-cleaning strainers for water circulating systems handling flows up to 180,000 gallons per hour.

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Wire-wound filters for the protection of hydraulic systems at pressures up to 5,000 lbs. per square inch.

AUTO-KLEAN FLUSHFLO
Self-cleaning wire-wound filters for fully automatic protection of water and oil circulating systems at flows at up to 400,000 gallons per hour.

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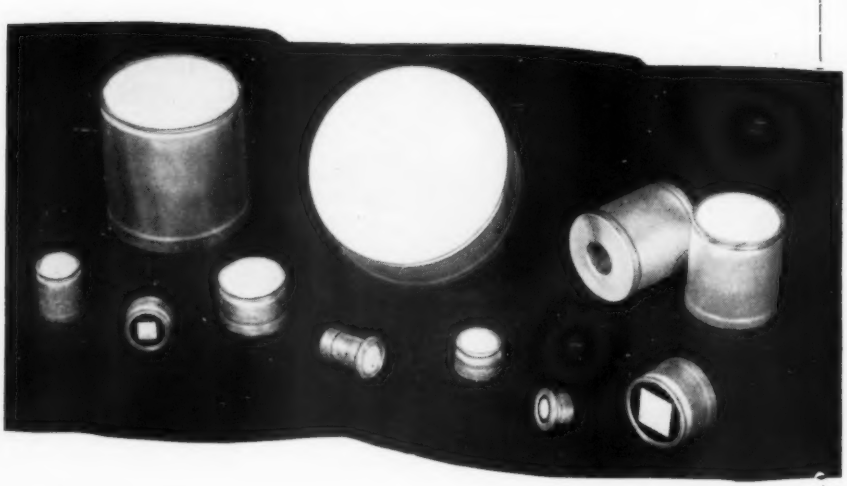

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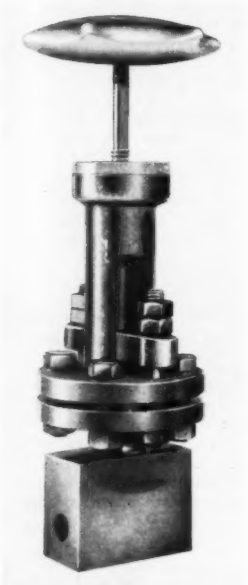

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TYPE C505

GYP

This design has been introduced to meet the requirements for a valve to handle fluids and gases at temperatures up to and including 600°C.

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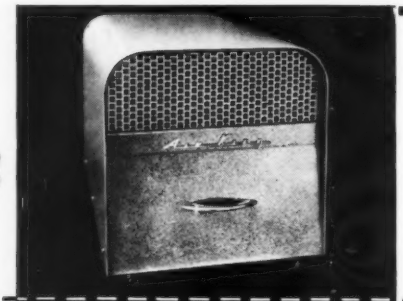
temperature control and air conditioning in industry



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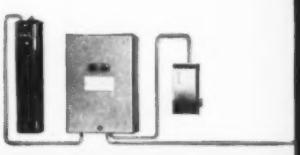

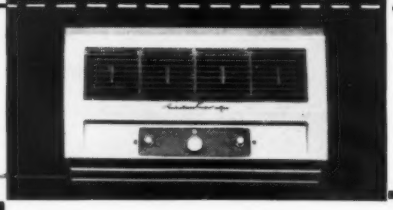

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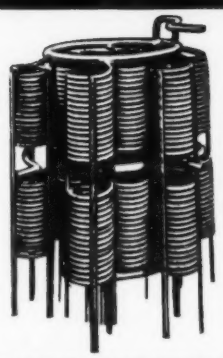

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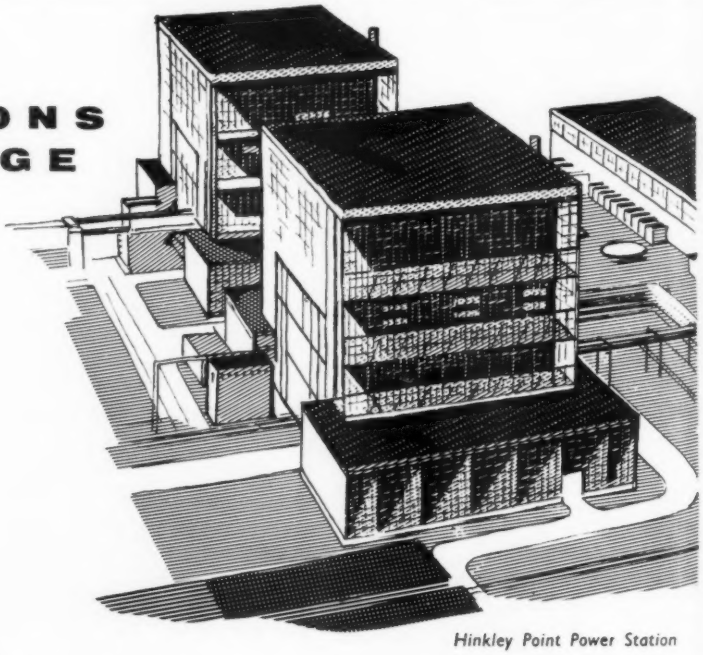

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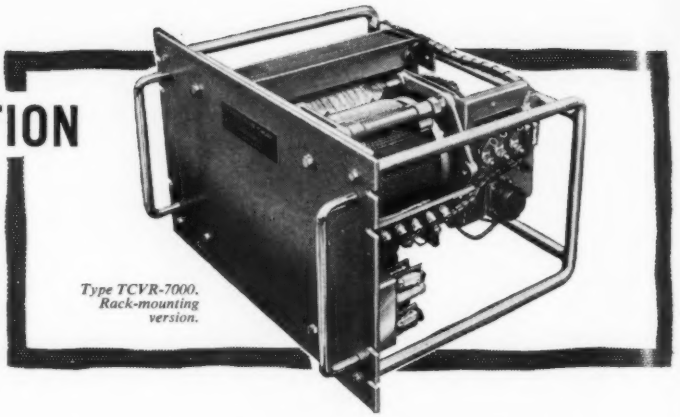
40 VOLTS/SEC AUTOMATIC CORRECTION

—with the type TCVR voltage regulator

The TCVR is a servomechanical automatic voltage regulator having the very high speed of correction of FORTY VOLTS PER SECOND. It provides an *undistorted* output, maintained constant within very close limits (normally ±0.5%) from no-load to full-load, for wide variations in frequency and power factor.

A wide range of models from 1.6 to 12 kVA single-phase, and 4.8 to 36 kVA three-phase, is available, to standard or tropical specification, in cabinets or for rack-mounting. Models are also available in which the output voltage is continuously adjustable over a wide range by means of a panel control. Regulators can be supplied to Services' specification, and special models can be designed to order.

For high-speed, accurate stabilisation *without distortion*—**specify TCVR.**



Type TCVR-7000. Rack-mounting version.

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Other products of Claude Lyons Ltd. Stabiliser Division

BMVR: Motor-driven laboratory and industrial regulators ranging from 1·6 to 29 kVA single-phase, and 4·8 to 87 kVA three-phase. Constancy of output normally ± 0·5% from no-load to full-load. No distortion. Speed of correction 1 Volt/Sec. A great variety of models, standard, tropical and militarised, for all applications.

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ATC: Automatic Tap-Changing Transformers — a development of ASR. Two sizes : 575 VA and 1150 VA. Input range − 20% to + 10% : output constancy, ± 5%. Provide adequate stabilisation for many types of apparatus, at low cost. Also useful as pre-regulators, e.g. in conjunction with BAVR.

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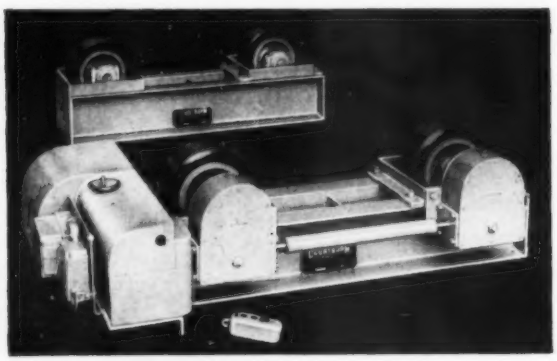
Rotator sets are made in sizes of 2 tons to 200 tons capacity.



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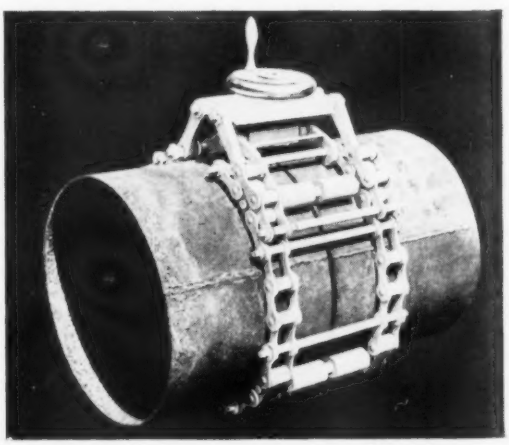
The illustration shows a model 612—Courtburn Adjustable Pipe Clamp. The clamp is holding and aligning two short lengths of 10 in. N.B. pipe. Ample accessibility is provided for tack welding all round the pipes, and space can be left between the pipe ends for the weld filler as required.

This is one of the range of three adjustable clamps, each light enough for the operator to handle with ease. These moderately priced clamps will cater for all sizes from 6 in. to 24 in.



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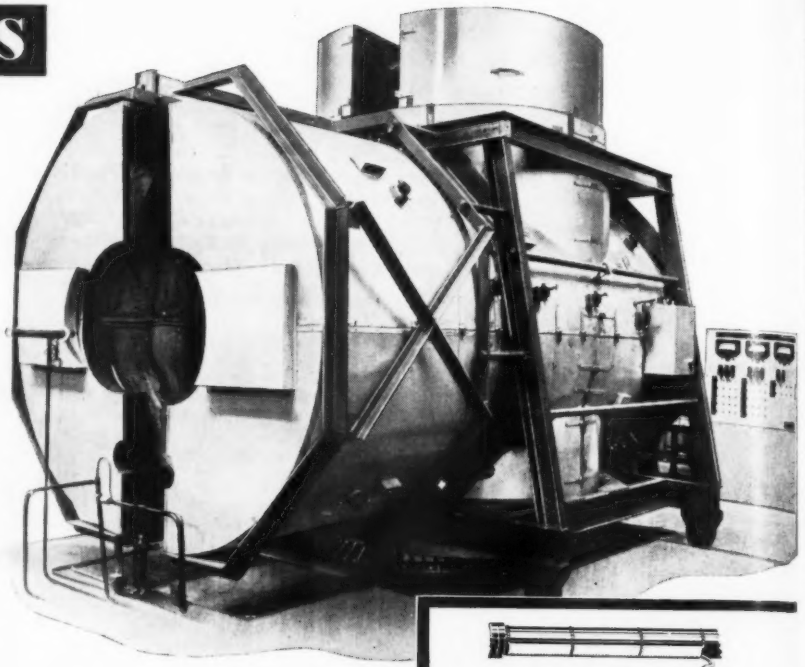

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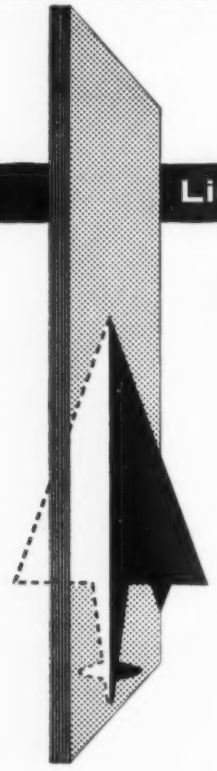

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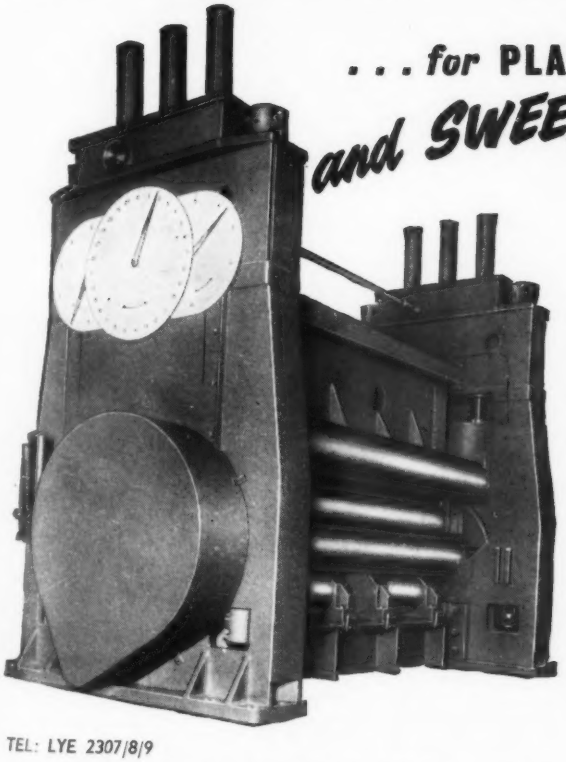
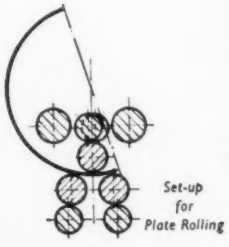
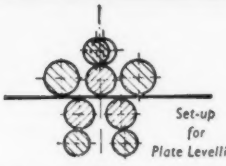




Set-up for Plate Rolling



Set-up for Plate Levelling

This dual purpose Bronx Machine is specially designed for levelling plate up to 12ft. in width by 1½in. in thickness, down to ⅜in. in thickness. With the two outer rolls in the "up" position as shown in the illustration, the machine will also roll plate to a minimum radius of 2ft. The machine does not roll complete circles but will form sweeps, or radii, to a minimum half-circle of 4ft. diameter. Suitable, as it is, for both plate levelling and sweep rolling, it presents a most economical combination of machines.

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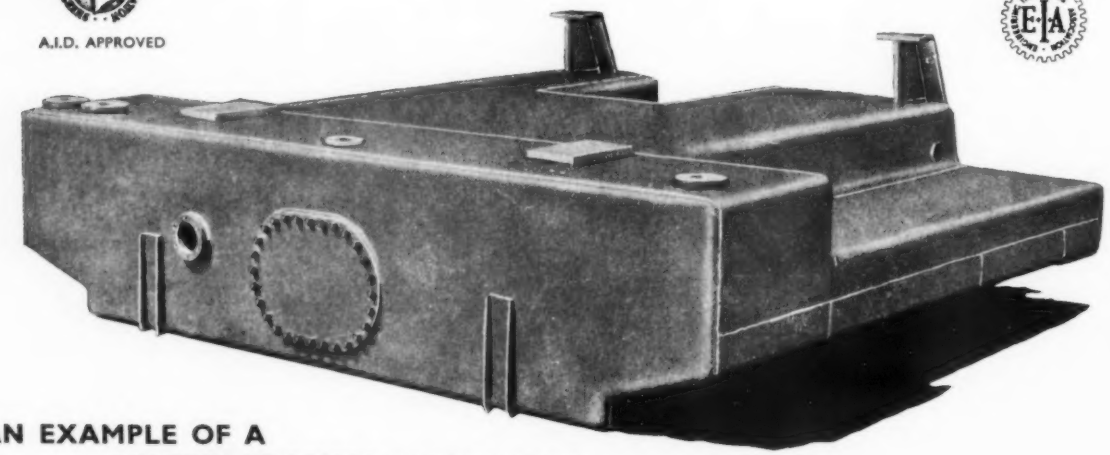

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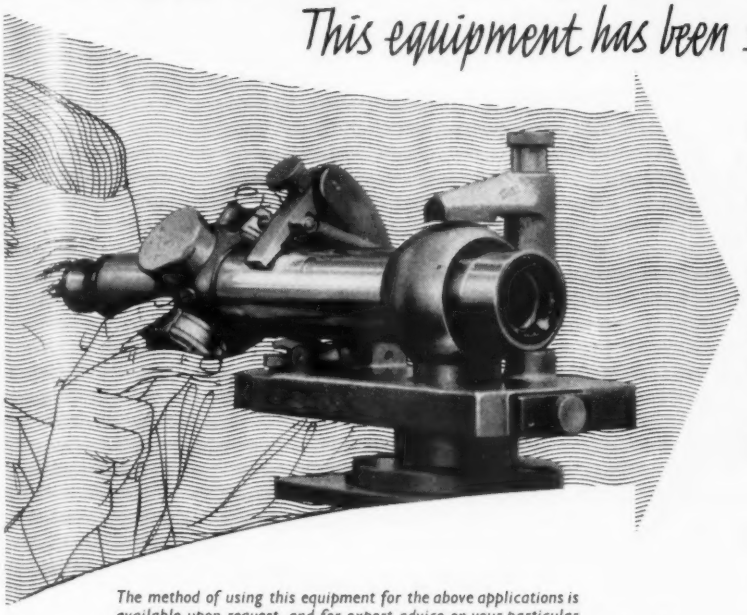

. . . the United Kingdom Atomic Engineering Research Establishment in the construction of Experimental Nuclear Reactors and the associated Projects ZETA, BEPO, ZEUS, ZEPHYR, DIDO and PLUTO. Also used by the leading manufacturing groups in the construction of Nuclear Power Stations, of the Power Supply Plan in Great Britain.

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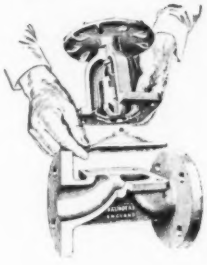

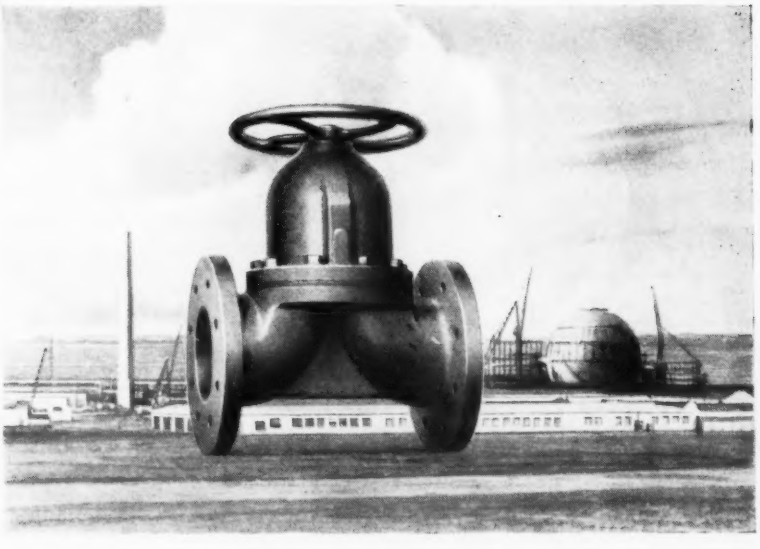

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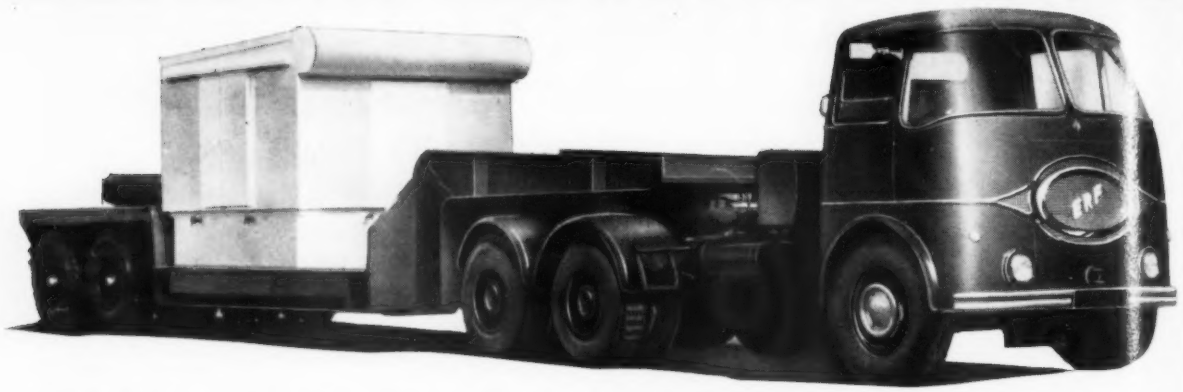

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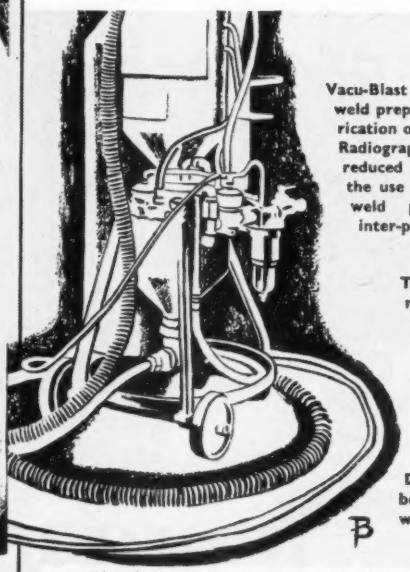

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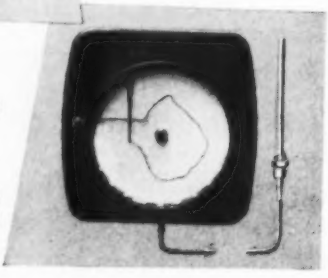

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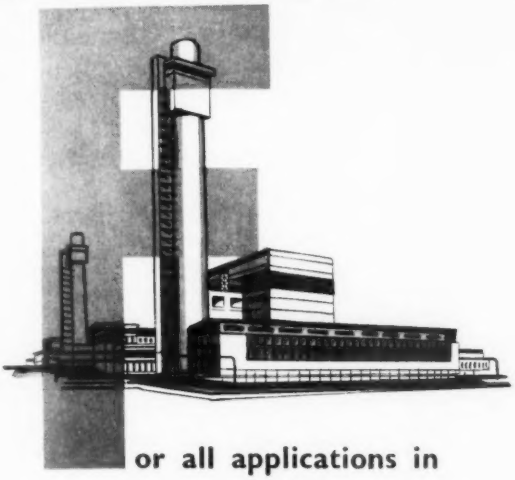

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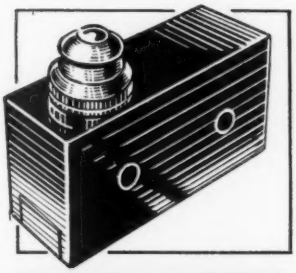

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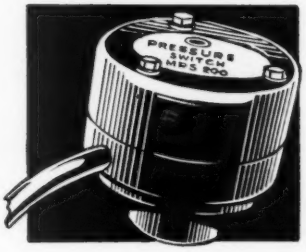

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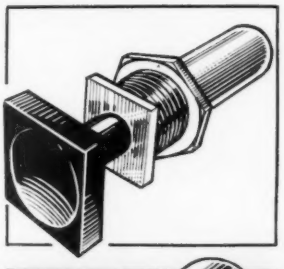

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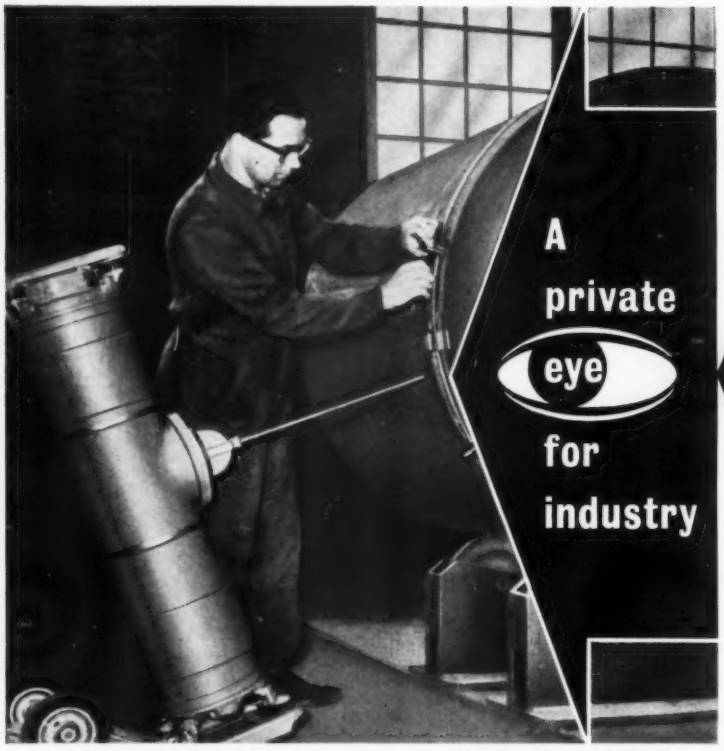

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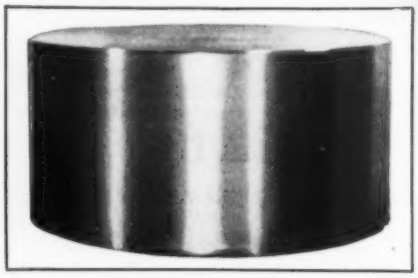

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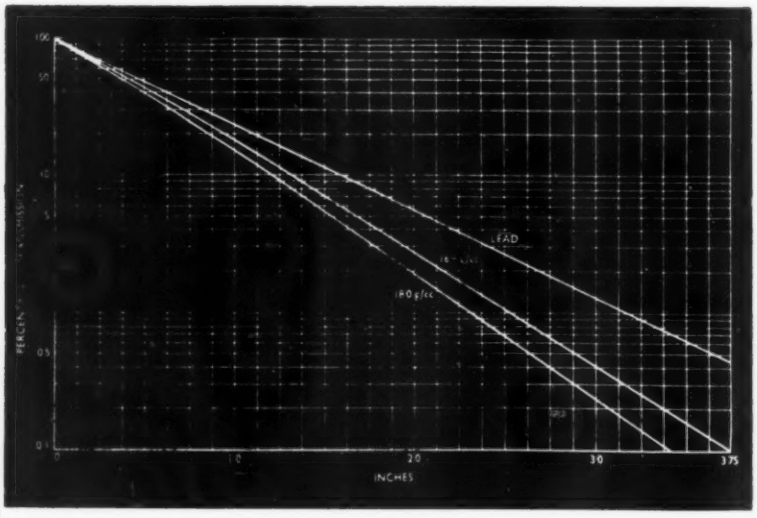

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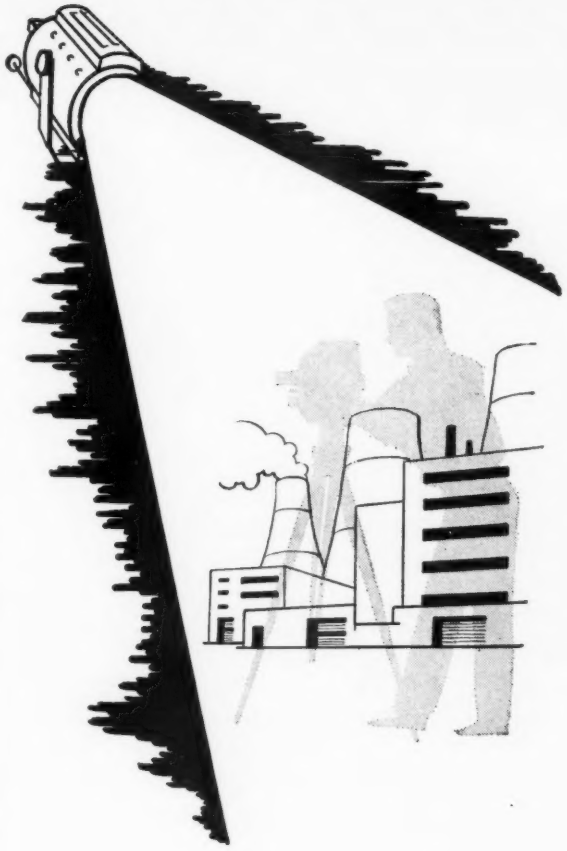

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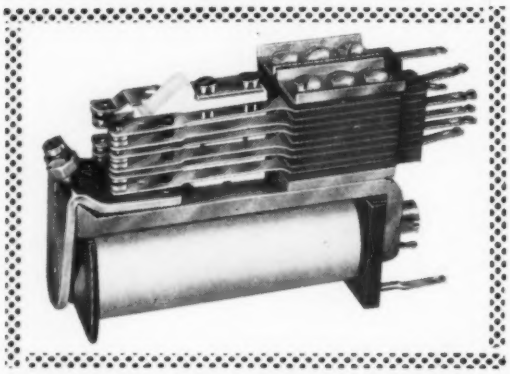

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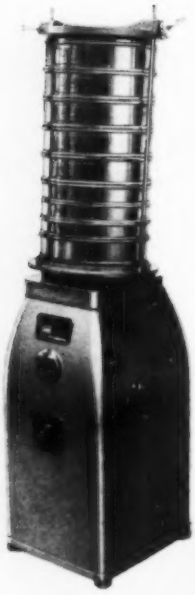

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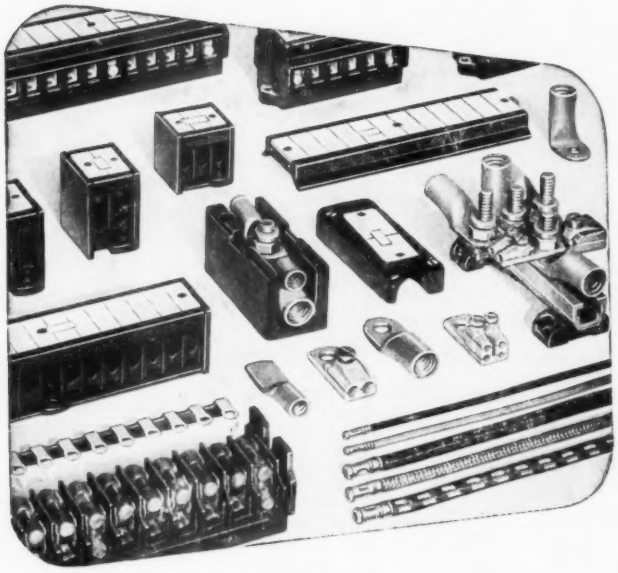

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(NUCLEAR DATA)

By Dr. rer. nat. **WUNIBALD KUNZ,** Vienna and Prof. Dr. phil. **JOSEF SCHINTLMEISTER** Director, Institute for Experimental Nuclear Research, Technische Hochschule, Dresden.

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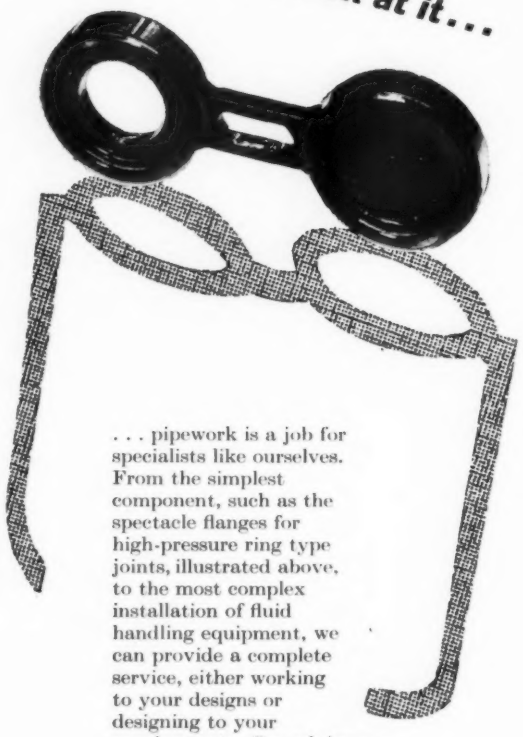

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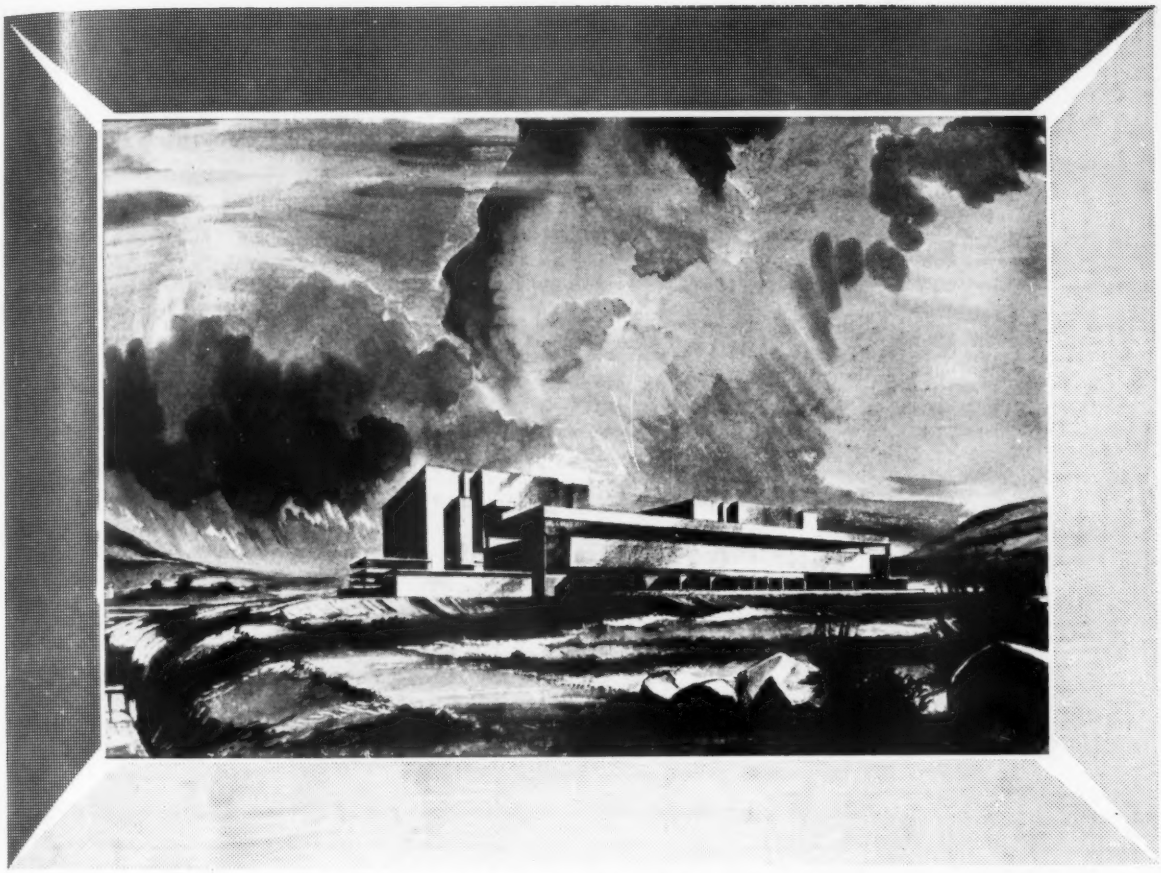

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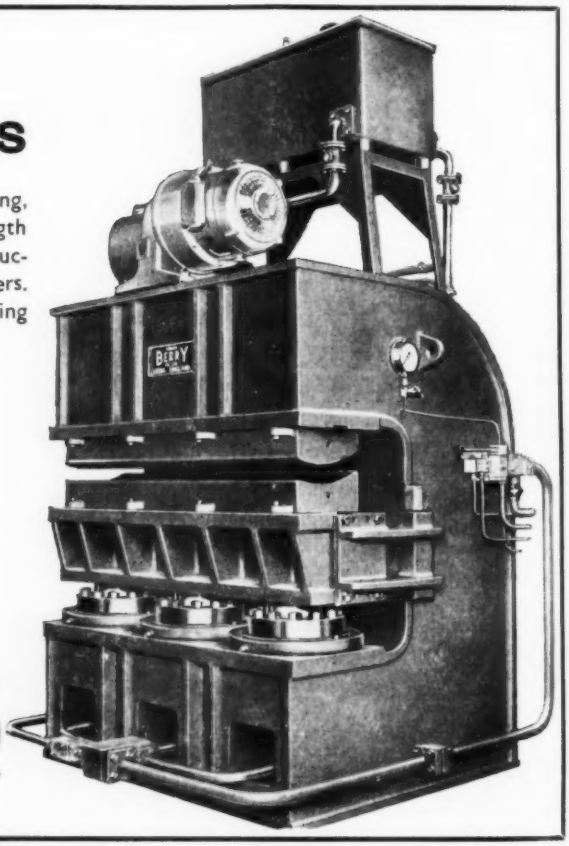

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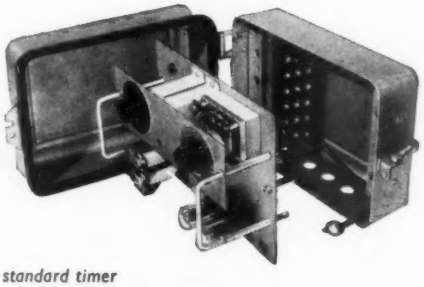

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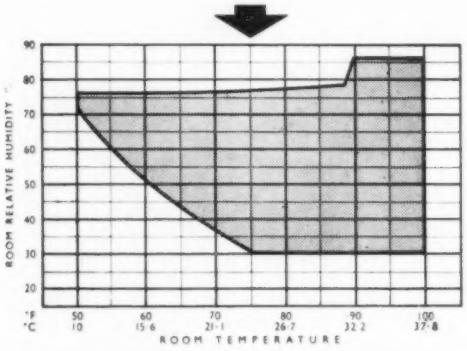

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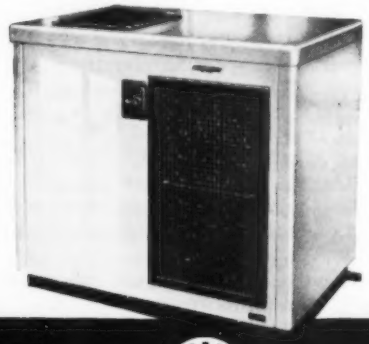

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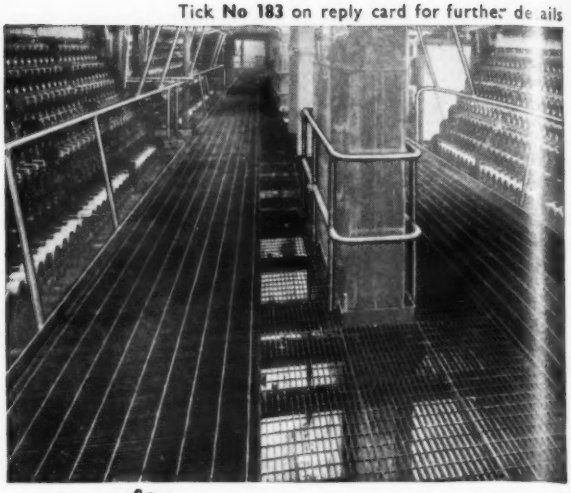

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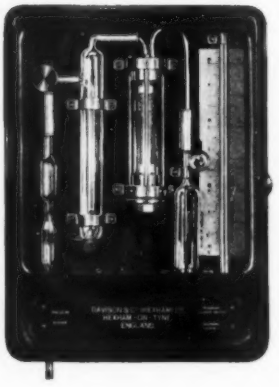

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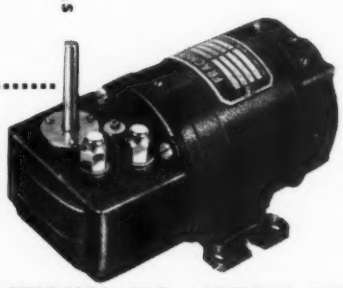

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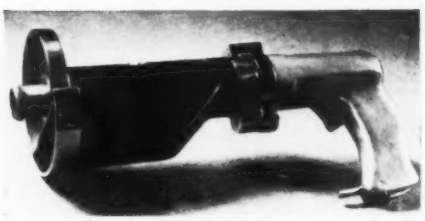

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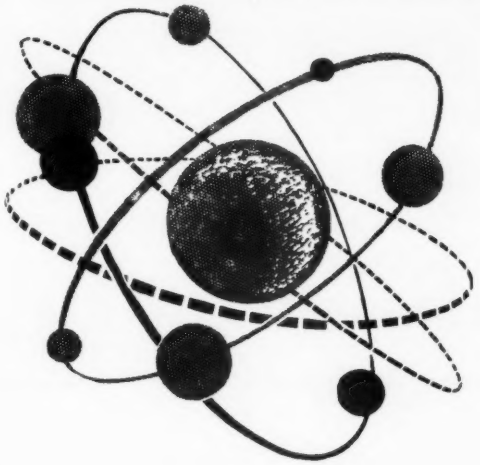

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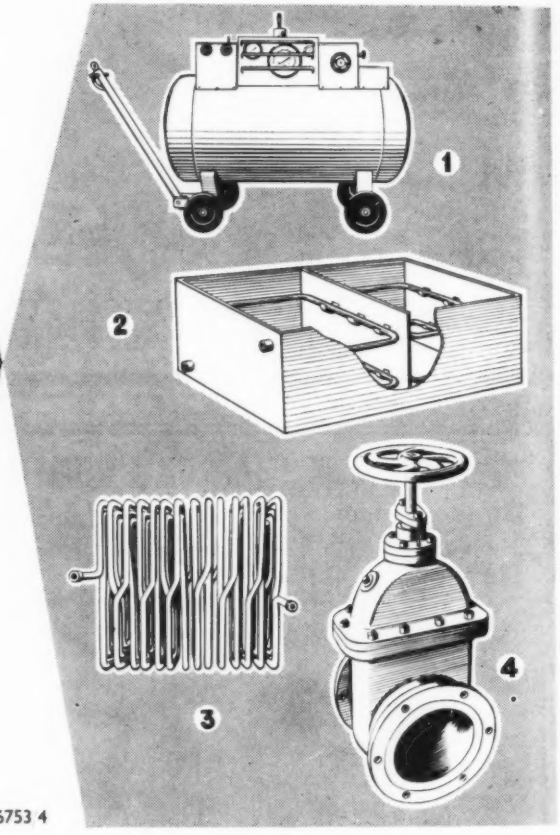

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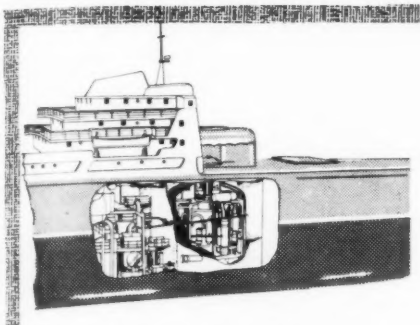

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The successful applicant will be required to assist the Site Electrical Engineer in the supervision and commissioning of instrumentation in connection with both conventional and nuclear plant.

Applicants should have some works experience or apprenticeship training and previous experience on installation and commissioning of instruments and control equipment is essential. Experience in the nuclear instrumentation field is not essential, but would be an advantage.

Applicants should have qualifications up to Higher National Certificate and should preferably be Corporate Members of the Institution of Electrical Engineers.

This is a permanent appointment, and the successful candidate will be expected to live in the vicinity of the site for the duration of the construction work, which will be approximately three years. Opportunities will be available for transfer to future generating station sites and to the design teams associated with these stations.

The salary for the appointment will be within Grade 4 of Schedule 'C' of the N.J.B. Agreement, i.e. £1,195-£1,545 per annum, according to qualifications and experience.

Applications stating age, qualifications, experience, present position and salary should be forwarded to the Administrative Officer, Central Electricity Generating Board, Southern Project Group, Squires Lane, Finchley, London, N.3, to arrive not later than Monday, 1st February, 1960.

Envelopes should be marked "Confidential—S/60/6."

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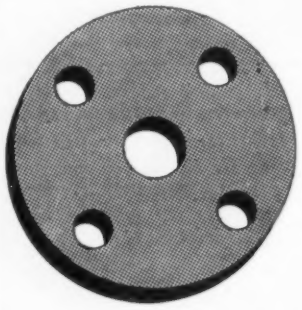

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773	795	817	839	861	883	905	927	949	971	993					
774	796	818	840	862	884	906	928	950	972	994					
775	797	819	841	863	885	907	929	951	973	995					
776	798	820	842	864	886	908	930	952	974	996					
777	799	821	843	865	887	909	931	953	975	997					
778	800	822	844	866	888	910	932	954	976	998					
779	801	823	845	867	889	911	933	955	977	999					

NAME .....

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Nuclear Power Buyers' Guide 1960

308	338	368	398	428	458	488	518	548	578	608	638	668	698	728	
309	339	369	399	429	459	489	519	549	579	609	639	669	699	729	
310	340	370	400	430	460	490	520	550	580	610	640	670	700	730	
311	341	371	401	431	461	491	521	551	581	611	641	671	701	731	
312	342	372	402	432	462	492	522	552	582	612	642	672	702	732	
313	343	373	403	433	463	493	523	553	583	613	643	673	703	733	
314	344	374	404	434	464	494	524	554	584	614	644	674	704	734	
315	345	375	405	435	465	495	525	555	585	615	645	675	705	735	
316	346	376	406	436	466	496	526	556	586	616	646	676	706	736	
317	347	377	407	437	467	497	527	557	587	617	647	677	707	737	
318	348	378	408	438	468	498	528	558	588	618	648	678	708	738	
319	349	379	409	439	469	499	529	559	589	619	649	679	709	739	
320	350	380	410	440	470	500	530	560	590	620	650	680	710	740	
321	351	381	411	441	471	501	531	561	591	621	651	681	711	741	
322	352	382	412	442	472	502	532	562	592	622	652	682	712	742	
323	353	383	413	443	473	503	533	563	593	623	653	683	713	743	
324	354	384	414	444	474	504	534	564	594	624	654	684	714	744	
325	355	385	415	445	475	505	535	565	595	625	655	685	715	745	
326	356	386	416	446	476	506	536	566	596	626	656	686	716	746	
327	357	387	417	447	477	507	537	567	597	627	657	687	717	747	
328	358	388	418	448	478	508	538	568	598	628	658	688	718	748	
329	359	389	419	449	479	509	539	569	599	629	659	689	719	749	
330	360	390	420	450	480	510	540	570	600	630	660	690	720	750	
331	361	391	421	451	481	511	541	571	601	631	661	691	721	751	
332	362	392	422	452	482	512	542	572	602	632	662	692	722	752	
333	363	393	423	453	483	513	543	573	603	633	663	693	723	753	
334	364	394	424	454	484	514	544	574	604	634	664	694	724	754	
335	365	395	425	455	485	515	545	575	605	635	665	695	725	755	
336	366	396	426	456	486	516	546	576	606	636	666	696	726	756	
337	367	397	427	457	487	517	547	577	607	637	667	697	727	757	
758	780	802	824	846	868	890	912	934	956	978					
759	781	803	825	847	869	891	913	935	957	979					
760	782	804	826	848	870	892	914	936	958	980					
761	783	805	827	849	871	893	915	937	959	981					
762	784	806	828	850	872	894	916	938	960	982					
763	785	807	829	851	873	895	917	939	961	983					
764	786	808	830	852	874	896	918	940	962	984					
765	787	809	831	853	875	897	919	941	963	985					
766	788	810	832	854	876	898	920	942	964	986					
767	789	811	833	855	877	899	921	943	965	987					
768	790	812	834	856	878	900	922	944	966	988					
769	791	813	835	857	879	901	923	945	967	989					
770	792	814	836	858	880	902	924	946	968	990					
771	793	815	837	859	881	903	925	947	969	991					
772	794	816	838	960	882	904	926	948	970	992					
773	795	817	839	861	883	905	927	949	971	993					
774	796	818	840	862	884	906	928	950	972	994					
775	797	819	841	863	885	907	929	951	973	995					
776	798	820	842	864	886	908	930	952	974	996					
777	799	821	843	865	887	909	931	953	975	997					
778	800	822	844	866	888	910	932	954	976	998					
779	801	823	845	867	889	911	933	955	977	999					

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The NUCLEAR POWER Year Book and Buyers' Guide, published separately as a companion reference book to NUCLEAR POWER, and the only comprehensive guide of its kind for management, research workers, operators, and others, contains the fullest information available of British firms supplying goods and services for the atomic energy industry. This coloured section is a much condensed version of the Buyers' Guide Section of the Year Book arranged for easy reference. The 3rd Edition of the Year Book also includes articles and tables on reactor physics, instrumentation and metallurgy, isotope and reactor data, in addition to biographical notes on important personalities in the industry. The Year Book is obtainable from Rowse Muir Publications Ltd, 3 Percy St, London W1, England, at £2.12.6—post paid.

February 1960

Nuclear Power Buyers' Guide

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Company Addresses **Page 31**

PRODUCT CLASSIFICATION

Section 1

Materials, plant, equipment, services

ACTUATORS—ELECTRO-MECHANICAL
★ Circle **No 308** on reply card
Allied Electronics Ltd
Bell Precision Engineering Co Ltd
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
English Electric Co Ltd, The
Hobson Ltd, H. M.
Lancashire Dynamo Electronic Products Ltd
LimiTorque Valve Controls Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Nucleonics Ltd
Rotax Ltd
Stewart Aeronautical Ltd
Teleflex Products Ltd
Weyers Bros Ltd

ACTUATORS—HYDRAULIC
★ Circle **No 309** on reply card
Baldwin Instrument Co Ltd.
Bell Precision Engineering Co Ltd
Chamberlain Industries Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Hobson Ltd, H. M.
Keelavite Hydraulics Ltd
LimiTorque Valve Controls Ltd
Lockheed Precision Products Ltd
Martonair Ltd
Plessey Nucleonics Ltd
Screw Machine Products Ltd
Stewart Aeronautics Ltd
Telehoist Ltd

ACTUATORS—PNEUMATIC
★ Circle **No 310** on reply card
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
Bell Precision Engineering Co Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elliott Brothers (London) Ltd
Elliott Nucleonics Ltd
Fairey Aviation Co Ltd, The
Globe Pneumatic Engineering Co Ltd
Gordon & Co Ltd, James
Kent Ltd, George
Leybold Vacuum Sales Ltd
LimiTorque Valve Controls Ltd
Martonair Ltd
Plessey Nucleonics Ltd
Rotax Ltd
Screw Machine Products Ltd
T.A.L. Numatics Ltd

AGGREGATES—SPECIAL DENSE
★ Circle **No 311** on reply card
Chatwood-Milner Ltd
Barytes (Shielding Products) Ltd
Cornwall Mills Ltd
Head Wrightson Teesdale Ltd
United Chemicals (London) Ltd

AIR COMPRESSORS (*See Compressors—Air*)

AIR COOLERS
★ Circle **No 312** on reply card
Adamson & Co Ltd, Daniel
Aerospray Associated Ltd
Biddle Ltd, F. H.
Birlec Ltd
Birwelco Ltd
Broom & Wade Ltd
Brown Fintube (GB) Ltd
Burnett & Lewis Ltd
Capper & Co Ltd, William H.
Carrier Engineering Co Ltd
Davidson & Co Ltd
English Electric Co Ltd, The
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Heenan & Froude Ltd
Holmes Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Ingersoll-Rand Ltd
Intermit Ltd
Lacy-Hulbert & Co Ltd
Lightfoot Refrigeration Co Ltd, The
Mancuna Engineering Ltd
Matthews & Yates Ltd
Morfax Ltd
Musgrave & Co Ltd
Newton, Chambers & Co Ltd
Plannair Ltd
Premier Cooler & Engineering Co Ltd, The
Spiral Tube & Components Ltd
Spiro-Gills Ltd
Sturtevant Engineering Co Ltd
Superheater Co Ltd, The
Thermocontrol Installations Co Ltd
United Air Coil Ltd
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd
Wykeham & Co Ltd, W.

AIR DRIERS
★ Circle **No 313** on reply card
Aerox Ltd
Apex Construction Ltd
Biddle Ltd, F. H.
Birlec Ltd
Birwelco Ltd
British CECA Ltd
Burnett & Lewis Ltd
Cargocaire Ltd
Davidson & Co Ltd
Hargreaves & Sons Ltd, Henry
Heat Transfer Ltd
Holmes Ltd
Incandescent Heat Co Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Magnetic Equipment Co Ltd, The
Mancuna Engineering Ltd
Newton, Chambers & Co Ltd
Plannair Ltd
Rotax Ltd
Williams & James (Engineers) Ltd
Wykeham & Co Ltd, W.

AIR FILTERS—ADSORPTION
★ Circle **No 314** on reply card
Aerox Ltd
Air Control Installations Ltd
Birlec Ltd
Birwelco Ltd
British CECA Ltd
Broom & Wade Ltd
Burnett & Lewis Ltd
Doulton Industrial Porcelains Ltd
Holmes Ltd
Incandescent Heat Co Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Kestner Evaporator & Engineering Co Ltd
Mancuna Engineering Ltd
Ozonair Engineering Co Ltd
Premier Cooler & Engineering Co Ltd, The
Silica Gel Ltd
Spembly Ltd
Standard & Pochin Bros Ltd, The
Sunvic Controls Ltd
Western Detail Mfrs Ltd
Wykeham & Co Ltd, W.

AIR FILTERS—DRY, CLEANABLE
★ Circle **No 315** on reply card
Aerospray Associated Ltd
Aerox Ltd
Air Control Installations Ltd
Andrew Machine Construction Co Ltd, The
Birflo Controls Ltd
Bivac Air Co Ltd
Burnett & Lewis Ltd
Cape Asbestos Co Ltd
Carlson Ltd, John C.

AIR FILTERS—*continued*
Dallow Lambert & Co Ltd
Doulton Industrial Porcelains Ltd
Harris Engineering Co Ltd
Heather Filters Ltd
Holmes Ltd
Incandescent Heat Co Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Jeffreys & Co Ltd, J.
Keith Blackman Ltd
Lockheed Precision Products Ltd
Mancuna Engineering Ltd
Norgren Ltd, C. A.
Ozonair Engineering Co Ltd
Premier Cooler & Engineering Co Ltd
Sintered Products Ltd
South London Electrical Equipment Co Ltd
Stillite Products Ltd
Stream-Line Filters Ltd
Sturtevant Engineering Co Ltd
Taylor Controls Ltd
Tilghman's Ltd
Vokes Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd
Wykeham & Co Ltd, W.

AIR FILTERS—DRY, DISPOSABLE
★ Circle **No 316** on reply card
Aeraspray Associated Ltd
Aerox Ltd
Air Control Installations Ltd
Burgess Products Co Ltd
Burnett & Lewis Ltd
Cape Asbestos Co Ltd
Carlson Ltd John C.
Doulton Industrial Porcelains Ltd
Fibreglass Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Jeffreys & Co Ltd, J.
Keith Blackman Ltd
Mancuna Engineering Ltd
Matthews & Yates Ltd
Ozonair Engineering Co Ltd
South London Electrical Equipment Co Ltd
Standard & Pochin Bros Ltd, The
Stillite Products Ltd
Sturtevant Engineering Co Ltd
T.A.L. Numatics Ltd
Visco Engineering Co Ltd
Vokes Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd
Wykeham & Co Ltd, W.

AIR FILTERS—VISCOUS, CLEANABLE
★ Circle **No 317** on reply card
Air Control Installations Ltd
Air-Maze Ltd
Andrew Machine Construction Co Ltd, The
Birfield Industries Ltd
Burgess Products Co Ltd
Intermit Ltd
IV Pressure Controllers Ltd
Keith Blackman Ltd
Lockheed Precision Products Ltd
Mancuna Engineering Ltd
Matthews & Yates Ltd
Metal & Plastic Compacts Ltd
Premier Cooler & Engineering Co Ltd
Sturtevant Engineering Co Ltd
Thermotank Ltd
Visco Engineering Co Ltd
Vokes Ltd
Western Detail Mfrs Ltd

AIR FILTERS—VISCOUS, DISPOSABLE
★ Circle **No 318** on reply card
Air Control Installations Ltd
Air-Maze Ltd
IV Pressure Controllers Ltd
Ozonair Engineering Co Ltd
Vokes Ltd
Western Detail Mfrs Ltd

AIR HEATERS—ELECTRIC
★ Circle **No 319** on reply card
Adamson & Co Ltd, Daniel
AEW Ltd
Air-Maze Ltd
Appleby & Ireland Ltd
Barlow-Whitney Ltd
Bastian & Allen Ltd
Biddle Ltd, F. H.
Controlled Heat & Air Ltd
Eltron (London) Ltd
Fenton, Burn & Co Ltd
General Electric Co Ltd, The
Hanovia Lamps
Harris Engineering Co Ltd
Heat Transfer Ltd
Matthews & Yates Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Plannair Ltd
Royce Electric Furnaces Ltd
Siemens Edison Swan Ltd
Spiral Tube & Components Ltd
Technograph Ltd

AIR HOISTS
★ Circle **No 320** on reply card
Atlas Copco Ltd
Broom & Wade Ltd
Consolidated Pneumatic Tool Co Ltd, The
Globe Pneumatic Eng Co Ltd
Ingersoll-Rand Ltd
Lang Pneumatic Ltd
Martonair Ltd
Sykes Ltd, Henry

ALTERNATORS (*See Generators etc*)

BEARINGS—BALL
★ Circle **No 321** on reply card
Autoset (Productions) Ltd
BMB (Sales) Ltd
Bristol Siddeley Engines Ltd (recirculation)
Brockhouse & Co Ltd, J.
Cooper Roller Bearings Co Ltd
Crofts (Engineers) Ltd
Deloro Stellite Ltd
Fischer Bearings Co Ltd
Hoffman Mfg Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Ransom & Marles Bearing Co Ltd (and linear)
Skefko Ball Bearing Co Ltd, The
Stewart Aeronautical Ltd

BEARINGS—CORE SUPPORT
★ Circle **No 322** on reply card
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd

BEARINGS—FLEXIBLE
★ Circle **No 323** on reply card
Cooper Roller Bearings Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Silentbloc Ltd
Skefko Ball Bearing Co Ltd, The

BEARINGS—ROLLER
★ Circle **No 324** on reply card
Allen & Sons (Tipton) Ltd, W. G.
British Timken Ltd
Cooper Roller Bearings Co Ltd
Croft (Engineers) Ltd
Fischer Bearings Co Ltd
Hoffmann Mfg Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd
Salter Ltd, G.
Skefko Ball Bearing Co Ltd, The

BEARINGS—THRUST
★ Circle **No 325** on reply card
Armstrong Siddeley Motors Ltd
BMB (Sales) Ltd
Cooper Roller Bearings Co Ltd
Deloro Stellite Ltd
Fischer Bearings Co Ltd
Insley (London) Ltd
Pollard Bearings Ltd
Ransome & Marles Bearing Co Ltd
Skefko Ball Bearing Co Ltd, The

BLOWERS (*See Circulators—Gas*)
BOILERS—ELECTRODE
★ Circle **No 326** on reply card
Bastian & Allen Ltd
Brown Land Boilers Ltd, John
Butterfield Ltd, W. P.
Foster Wheeler Ltd
Head Wrightson Processes Ltd
Robey & Co Ltd

BOLTS & NUTS
★ Circle **No 327** on reply card
Macnays Ltd
Mountford Ltd, F. (s.s., also pins and keys)
Rubery Owen Ltd (Darlaston)

BRUSHWARE—INDUSTRIAL
★ Circle **No 328** on reply card
Baddeley Engineering Co Ltd, D. S.
Dendix Brushes Ltd
Kleen-E-Ze Brush Co Ltd
Gem Power Brushes Ltd
Industrial Descaling Tools Ltd
Morris Ltd, B. O.

BUBBLE CAPS & TRAYS
★ Circle **No 329** on reply card
Allen & Sons (Tipton) Ltd, W. G.
APV Co Ltd, The
Babcock & Wilcox Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Constructors—John Brown Ltd
Dempster Ltd
Dore Ltd
Foster Wheeler Ltd
Fraser & Co Ltd, W. J.
Hathernware Ltd
Head Wrightson Teesdale Ltd
Holmes Ltd
International Meehanite Metal Co Ltd, The
Metal Propellers Ltd
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
OVF Ltd
Taylor Rustless Fittings Ltd
Thompson Bros (Bilston) Ltd
Wykeham Ltd

BURST SLUG DETECTION APPARATUS
(*See Gas Sampling Plant, Sec. 2*)

CABLES—ELECTRIC
★ Circle **No 330** on reply card
ASEA Electric Ltd
Bayley, Clanahan Ltd (thermocouple compensated)
British Insulated Callender's Cables Ltd
Crompton Parkinson Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Henley's Telegraph Works Co Ltd, W. T.
Irish Cables Ltd
Johnson & Phillips Ltd
Kaye Ltd, E & E.
Leland Instruments Ltd
Pyrotenax Ltd (mineral insulated)
Siemens Edison Swan Ltd
Southern Forge Ltd (aluminium alloy)
Standard Telephones & Cables Ltd
Stewart Aeronautical Ltd
Tangyes Ltd (all types)
Telegraph Construction & Maintenance Co Ltd
TI Nuclear Engineering Ltd
Wandleside Cable Works Ltd
Wykeham Ltd

CARBON PRODUCTS
★ Circle **No 331** on reply card
Bayley Clanahan Ltd
Vickers-Armstrong (A/c) Ltd
British Acheson Electrodes Ltd
General Refractories Ltd
Leland Instruments Ltd
Morgan Crucible Co Ltd
Norbrac Carbon Ltd
Powell Duffryn Carbon Products Ltd
Spembly Ltd

CASTINGS—FERROUS (*See Steel*)

CASTINGS—NON-FERROUS
★ Circle **No 332** on reply card
Andrews & Platt (Engineers) Ltd (all types)
Anti-Attrition Co Ltd (all types)
Appleton & Howard Ltd (bronze & lead)
APV Ltd (aluminium)
Armstrong Whitworth (Met. Ind.) Ltd
Ashwell & Nesbit Ltd
Bells Asbestos Ltd
Birfield Industries Ltd
Birkett, Billington & Newton Ltd
Birmingham Aluminium Casting Ltd (Al, Mg)
Blundell & Crompton Ltd (bronze, gunmetal, aluminium)
British Steam Specialties Ltd (gunmetal)
Brockhouse & Co Ltd, J. (all types)
Consolidated Zinc Corp (Sales) Ltd
Crosfield & Sons Ltd, Joseph
Deloro Stellite Ltd (cobalt & nickel base)
English Electric Co Ltd, The (all types)
Enthoven Ltd (lead)
Fowler Ltd (lead)
Fullers' Earth Union Ltd, The
Grey & Marten Ltd
Harland & Wolff Ltd (all types)
High Duty Alloys Ltd (aluminium alloy)
Hill Ltd, C. L. (al, brass, bronze)
Hindle & Sons Ltd, Joshua (bronze, nickel, monel)
Hull Ltd, F.
Imperial Chemical Industries Ltd
Langley Alloys Ltd (aluminium bronze)
Mills Packard Construction Co Ltd (lead)
Millspaugh Ltd (all types)
Monsanto Chemicals Ltd
Napier & Son Ltd, D.
Peters Ltd, G. D.
Roberts Ltd, R. E. (lead)
Robertson & Co Ltd, W. H. A. (aluminium, brass, bronze, gunmetal, aluminium-bronze, manganese-bronze, phosphor-bronze)
Rubery Owen Ltd (Darlaston)
Ryder & Co (Manchester) Ltd, Thomas (all types)
Sheepbridge Engineering Ltd
Sheffield Smelting Co Ltd, The (light alloys)

CELLS—ELECTROLYTIC
★ Circle **No 333** on reply card
Aerox Ltd
Doulton Industrial Porcelains Ltd
Hathernware Ltd
Imperial Chemical Industries Ltd
International Electrolytic Plant Co Ltd, The
Morgan Crucible Co Ltd, The
Simon-Carves Ltd
Wykeham Ltd

CELLS—HOT
★ Circle **No 334** on reply card
Head Wrightson Processes Ltd
Nuclear Engineering Ltd
Spembly Ltd
Western Detail Mfrs Ltd

CENTRIFUGES—INDUSTRIAL
★ Circle **No 335** on reply card
Aerox Ltd
Head Wrightson Teesdale Ltd
Lang London Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Sharples Centrifuges Ltd
Vicsons Ltd.
Wykeham Ltd

CERAMICS
★ Circle **No 336** on reply card
Aerox Ltd
Bayley Clanahan Ltd
Doulton Industrial Porcelains Ltd
English Clays, Lovering Pochin & Co Ltd
Guest Industrials Ltd
Hathernware Ltd
Hydronyl Syndicate Ltd
Leland Instruments Ltd
Lodge Plugs Ltd
Morgan Crucible Co Ltd, The
Podmore & Sons, Ltd, W.
Revo Electric Ltd
Steatite & Porcelain Products Ltd
Technical Ceramics Ltd
Thermal Syndicate Ltd, The

CERMETS
★ Circle **No 337** on reply card
Morgan Crucible Co Ltd, The
Technical Ceramics Ltd

CHARGE MACHINES—REACTOR FUEL
★ Circle **No 338** on reply card
Chatwood-Milner Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
Flight Refuelling Ltd
Motherwell Bridge & Engineering Co Ltd, The
Strachan & Henshaw Ltd
Thompson Ordnance Co, John
Vickers-Armstrongs (a/c) Ltd

CHARGE PANS
★ Circle **No 339** on reply card
APV Co Ltd
Chatwood-Milner Ltd
English Electric Co Ltd, The
Head Wrightson Teesdale Ltd
International Meechanite Metal Co Ltd

CHLORINATION PLANT
★ Circle **No 340** on reply card
Candy Filter Co Ltd, The
Heat Transfer Ltd
QVF Ltd
Wallace & Tiernan Ltd

CIRCULATORS—GAS, AXIAL FLOW
★ Circle **No 341** on reply card
Adamson & Co Ltd, Daniel
Air Control Installations Ltd
Alldays & Onions Ltd
Armstrong Siddeley Motors Ltd
British Thomson-Houston Co Ltd, The
Bryan Donkin Co Ltd, The
Callow (Engineers) Ltd, F. E.
Capper Ltd, Wm. H.
Davidson & Co Ltd
ECD Ltd
English Electric Co Ltd
General Electric Co Ltd, The
Hopkins & Co Ltd, F.
Howden & Co Ltd, James
Ingersoll-Rand Ltd
Johnson, Bromley & Co Ltd
Keith Blackman Ltd
Lacy-Hulbert & Co Ltd
Matthews & Yates Ltd
Musgrave & Co Ltd
Northey Rotary Compressors Ltd
Nuclear Power Plant Co Ltd, The
Parolle Electrical Plant Co Ltd
Parsons & Co Ltd, C. A.
Plannair Ltd
Ruston & Hornsby Ltd
Sturtevant Engineering Co Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd

CIRCULATORS—GAS, CENTRIFUGAL
★ Circle **No 342** on reply card
Adamson & Co Ltd, Daniel
Air Control Installations Ltd
Alldays & Onions Ltd
Bristol-Siddeley Engines Ltd (g/bearing)
British Thomson-Houston Co Ltd, The
Bryan Donkin Co Ltd, The
Callow (Engineers) Ltd, F. E.
Capper Ltd, Wm. H.
Crossley Bros Ltd
Davidson & Co Ltd
de Havilland Engine Ltd (g/bearing)
Dowty Nucleonics Ltd (g/bearing)
ECD Ltd
General Electric Co Ltd, The
Hopkins & Co Ltd, F.
Howden & Co Ltd, James
Ingersoll Rand Ltd
Johnson, Bromley & Co Ltd
Keith Blackman Ltd
Lacy-Hulbert & Co Ltd
Matthews & Yates Ltd
Musgrave & Co Ltd
Northey Rotary Compressors Ltd
Nuclear Power Plant Co Ltd, The
Parolle Electrical Plant Co Ltd
Parsons & Co Ltd, C. A.
Plannair Ltd
Reavell & Co Ltd
Ruston & Hornsby Ltd (g/bearing)
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

CLEANING EQUIPMENT—BOILER & HEAT EXCHANGER
★ Circle **No 343** on reply card
Airnesco Products Ltd
Consolidated Pneumatic Tool Co Ltd
Gem Power Brushes Ltd
General Descaling Co Ltd
Industrial Descaling Tools Ltd
Keith Blackman Ltd
Kleen-E-Ze Brush Co Ltd

COLUMN PACKINGS
★ Circle **No 344** on reply card
Constructors John Brown Ltd (Spraypak)
Doulton Industrial Porcelains Ltd
Foster Wheeler Ltd
Glass Developments Ltd
Griffin & George Ltd
Hathernware Ltd
Hydronyl Syndicate Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Scientific Furnishings Ltd
Thermal Syndicate Ltd, The
TI Nuclear Engineering Ltd

COLUMNS—ABSORPTION
★ Circle **No 345** on reply card
Adamson & Co Ltd, Daniel
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Butterworth Ltd, W. P.
Costain-John Brown Ltd
Davey, Paxman & Co Ltd
Dempster Ltd
Dore Ltd
Doulton Industrial Porcelains Ltd
Empyrium Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Guest Industrials Ltd
Harris (Birmingham) Ltd, F. & R. M.
Hathernware Ltd
Head Wrightson Teesdale Ltd
Heat Transfer Ltd
Holmes Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Mendip (Chemical Engineering) Ltd
Motherwell Bridge & Engineering Co Ltd, The
Newton, Chambers & Co Ltd
Powell Duffryn Carbon Products Ltd
QVF Ltd
Revo Electric Ltd
Rye-Arc Ltd
Scientific Furnishing Ltd
Simon-Carves Ltd
Thermal Syndicate Ltd, The
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Thompson Bros (Bilston) Ltd
Wykeham Ltd

COLUMNS—DISTILLATION
★ Circle **No 346** on reply card
Apex Construction Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Costain-John Brown Ltd
Davey, Paxman & Co Ltd
Dempster Ltd
Dore Ltd
Doulton Industrial Porcelains Ltd
Empyrium Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Giusti Ltd
Glass Developments Ltd
Griffin & George Ltd
Guest Industrials Ltd
Harvey & Co (London) Ltd, G. A.
Head Wrightson Processes Ltd
Heat Transfer Ltd
Holmes Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, Robert
Leybold Vacuum Sales Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Revo Electric Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Scientific Furnishings Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Taylor Rustless Fittings Ltd
Thermal Syndicate Ltd, The
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Thompson Bros (Bilston) Ltd
Watson & Co Ltd, Robert
Wykeham Ltd

COLUMNS—SOLVENT EXTRACTION
★ Circle **No 347** on reply card
Apex Construction Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Bennett Sons & Shears Ltd
Butterfield Ltd, W. P.
Davey, Paxman & Co Ltd
Dempster Ltd
Dore Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Guest Industrials Ltd
Head Wrightson Processes Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
QVF Ltd
Rye-Arc Ltd
Simon-Carves Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Wykeham Ltd

COMPRESSORS—AIR
★ Circle **No 348** on reply card
Adamson & Co Ltd, Daniel
Aerospray Associated Ltd
Air Pumps Ltd
Alley & MacLellan Ltd
Ashworth & Parker Ltd
Atlas Copco Ltd
Belliss & Morcom Ltd
B.E.N. Patents Ltd
British Thomson-Houston Co Ltd, The
Broom & Wade Ltd
Brotherhood Ltd, Peter
Budworth Ltd, David
Burtonwood Eng Ltd
Capper Ltd, W. H.
Chamberlain Industries Ltd
Chatwood-Milner Ltd
Consolidated Pneumatic Tool Co Ltd, The
CT (London) Ltd (glandless & leakproof)
Dowty Nucleonics Ltd
ECD Ltd
Edwards High Vacuum Ltd
English Electric Co Ltd, The
Hamworthy Engineering Ltd
Harland & Wolff Ltd
Holland Engineering Co Ltd, B. A.
Holmes Ltd
Howden & Co Ltd, James
Ingersoll-Rand Ltd
Joy-Sullivan Ltd
Keith Blackman Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Lloyd & Ross Ltd
Mackay Industrial Equipment
Mechanair
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Parsons & Co Ltd, C. A.
Reavell & Co Ltd
Richardsons, Westgarth & Co Ltd
Robey & Co Ltd
Rotax Ltd
Ruston & Hornsby Ltd
Stewart Aeronautical Ltd
Tecalemit, Ltd
Tilghman's Ltd
Wade Engineering Ltd
Weir Ltd, G. & J.
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

COMPRESSORS—GAS
★ Circle **No 349** on reply card
Alley & MacLellan Ltd
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter
Bryan Donkin Co Ltd, The
Capper Ltd, Wm. H.
CT (London) Ltd (glandless & leakproof)
Dowty Nucleonics Ltd
ECD Ltd
Guest Industrials Ltd
Hamworthy Engineering Ltd
Harland & Wolff Ltd
Holland Engineering Co Ltd, B. A.
Holmes Ltd
Howden & Co Ltd, James
Ingersoll-Rand Ltd
K.S.B. Ltd
Lloyd & Ross Ltd
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Parsons & Co Ltd, C. A.
Reavell & Co Ltd
Richardsons, Westgarth & Co Ltd
Robey & Co Ltd
Ruston & Hornsby Ltd
Tilghman's Ltd
Wade Engineering Ltd
Weir Ltd, G. & J.
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Worthington-Simpson Ltd

CONDENSERS—PROCESS
★ Circle **No 350** on reply card
Adamson, & Co Ltd, Daniel
Apex Construction Ltd
APV Co Ltd, The
Balfour & Co Ltd, Henry
Belliss & Morcom Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Butterfield Ltd W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Dore Ltd
Empyrium Ltd
Fraser & Co Ltd, W. J.
Harvey Ltd, G. A.
Harris (Birmingham) Ltd, F. & R. M.
Heat Transfer Ltd
Holmes Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, Robert
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Newton, Chambers & Co Ltd
Parsons & Co Ltd, C. A.
Pearson & Sons Ltd, T. B.
Power-Gas Corporation Ltd, The
QVF Ltd
Ryder & Co (Manchester) Ltd, Thos.
Scientific Furnishings Ltd
Serck Radiators Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Spiro-Gills Ltd
Taylor Rustless Fittings Ltd
Thompson (Dudley) Ltd, John
Thompson Bros (Bilston) Ltd
Unit Superheater & Pipe Co Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Worthington-Simpson Ltd
Wykeham Ltd

CONDENSERS—TURBINE
★ Circle **No 351** on reply card
Balfour & Co Ltd, Henry
Belliss & Morcom Ltd
Blundell & Crompton Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter
English Electric Co Ltd, The
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Harland & Wolff Ltd
Heat Transfer Ltd
Jenkins & Co Ltd, Robert
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co. Ltd, The
Parsons & Co Ltd, C. A.
Pearson & Sons Ltd, T. B.
Richardsons, Westgarth & Co Ltd
Ryder & Co (Manchester) Ltd, Thos.
Serck Radiators Ltd
Stanfield & Carver Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wykeham Ltd

CONTRACTORS—air conditioning
★ Circle **No 352** on reply card
Air Control Installations Ltd
Andrew Machine Construction Co Ltd, The
Biddle Ltd, F. H.
Birlec Ltd
Birmingham & Blackburn Construction Co Ltd
Brightside Heating & Engineering Co Ltd

CONTRACTORS—air conditioning *—continued*
Bullows & Sons Ltd, Alfred
Carrier Engineering Ltd
Colt Ventilation Ltd
Davidson & Co Ltd
Extrudex Ltd
Hargreaves & Sons Ltd, Henry
Heat Transfer Ltd
Honeywell Controls Ltd
Jeffreys & Co Ltd, J.
Mancuna Engineering Ltd
Matthews & Yates Ltd
Owen Power Plant Co
Press & Son Ltd, W.
Sturtevant Engineering Co Ltd
Supervents Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Thermotank Ltd
Visco Engineering Co Ltd, The
Walker & Co (Halifax) Ltd., P. M.
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Wykeham & Co Ltd, W.

CONTRACTORS—Building
★ Circle **No 353** on reply card
Balfour, Beatty & Co Ltd
Chivers & Sons Ltd, W. E.
Constructors-John Brown Ltd
Drake & Gorham Ltd
Holland and Hannen & Cubitts Ltd
Laing & Son Ltd, John
McAlpine & Sons Ltd, Sir Robert
Mitchell Engineering Ltd
Monk & Co Ltd, A.
Mowlem & Co Ltd, John
Nuclear Civil Constructors
Price, Charles R.
Simms Son & Cooke Ltd
Simon-Carves Ltd
Stokes, Taylor & Shaw Ltd
Taylor & Woodrow Construction Ltd
Trollope & Colls Ltd
United Steel Structural Co Ltd
Watson & Co Ltd, Robert
Whatlings Ltd

CONTRACTORS—Chemical Engineering
★ Circle **No 354** on reply card
Apex Construction Ltd.
Badger & Sons Ltd, E. B.
Bennett, Son & Shears Ltd
Blundell & Crompton Ltd
Constructors-John Brown Ltd
Dempster Ltd
Dore Ltd
Guest Industrials Ltd
Hawker Siddeley Nuclear Power Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Head Wrightson Teesdale Ltd
Holmes Ltd
Houseman & Thompson Ltd
Humphreys & Glasgow Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, R.
Jenkinson Ltd, W. G.
Kellogg International Corporation
Kestner Evaporator & Engineering Co Ltd
Mendip (Chem. Eng.) Ltd
Mills Packard Construction Co Ltd
Mason Ltd, G. Samuel
Newton, Chambers & Co Ltd
Nuclear Chemical Plant Ltd
Power-Gas Corporation Ltd
Procon (GB) Ltd
QVF Ltd
Shaw-Petrie Ltd
Simon-Carves Ltd.
Thompson (Dudley) Ltd, John
Walker Ltd, C. & W.
Ward, Ltd, Thos. W.
Winkworth Machinery Ltd

CONTRACTORS—Civil Engineering
★ Circle **No 355** on reply card
Ancorite Ltd
Balfour, Beatty & Co Ltd
Cementation Co Ltd
Chivers & Sons Ltd, W. E.
Constructors-John Brown Ltd
Dorman Long (Bridge & Engineering) Ltd
Henderson & Co Ltd, John M.
Holland and Hannen & Cubitts Ltd
Holemasters Ltd (rock & concrete drilling)
Howard & Co Ltd, John
Innes Ltd, J. K.
Kier & Co Ltd, J. L.
Laing & Sons Ltd, John
McAlpine & Sons Ltd, Sir Robert
Mears Bros (Contractors) Ltd
Mitchell Engineering Ltd
Mowlem & Co Ltd, John
Monk & Co Ltd, A.
Nuclear Civil Constructors
Price, Charles R.
Press & Son Ltd, William
Rubery Owen Ltd (Darlaston)
Simms Son & Cooke Ltd
Simon-Carves Ltd
Soil Mechanics Ltd (Piling)
Stokes, Taylor & Shaw Ltd
Taylor Woodrow Construction Ltd
Trollope & Colls Ltd
Turiff Construction Co Ltd
Whatlings Ltd

CONTRACTORS—Constructional Engineering
★ Circle **No 356** on reply card
Andrews & Platt (Engineers) Ltd
Appleby-Frodingham Steel Co
Austin & Sons (Dewsbury) Ltd, James
Bawn & Co Ltd, W. B. (Fabrication)
Birmingham & Blackburn Construction Co Ltd
Braby & Co Ltd, Frederick
Cleco Electric Ltd
Constructors-John Brown Ltd
Dempster Ltd
Dorman Long (Bridge & Engineering) Ltd
Drake & Gorham Ltd
Farmer & Son Ltd
Findlay & Co Ltd, Alex.
Gardner & Co Ltd, J.
General Steel & Iron Ltd
Guest Industrials Ltd
Haworth (ARC) Ltd (Flooring)
Head Wrightson Teesdale Ltd
Heat Exchangers Ltd
Hill & Smith Ltd
Hills (West Bromwich) Ltd
Holmes Ltd
Horseley Bridge & Thomas Piggott Ltd
Humphreys & Glasgow Ltd
Laing & Son Ltd, John
Lionweld Ltd
Mitchell Engineering Ltd
Motherwell Bridge & Engineering Co Ltd, The
Mowlem & Co Ltd, John
Musgrave & Co Ltd
Newton, Chambers & Co Ltd
Nuclear Civil Constructors
Press & Son Ltd, W.
Redpath, Brown & Co Ltd
Rubery Owen Ltd (Darlaston)
Savages Ltd
Sheet Metal Engineering Ltd
Simon-Carves Ltd
Stokes, Taylor & Shaw Ltd
Taylor Woodrow Construction Ltd
Tees-Side Bridge & Engineering Ltd
Thompson Industrial Constructions Ltd, John
Tileman & Co Ltd
Trollope & Colls Ltd
United Steel Companies Ltd, The
United Steel Structural Co Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos. W.
Watson & Co Ltd, Robert
Webb & Sons Ltd, Joseph
Whatlings Ltd
Wood & Co Ltd, Edward
Wright, Anderson & Co Ltd

CONTRACTORS—Electrical Engineering
★ Circle **No 357** on reply card
Bailey & Co Ltd, N. G.
Belmos Co Ltd, The
British Thomson-Houston Co Ltd, The
British Electrical Repairs Ltd
Cable Jointers Ltd
Cathodic Corrosion Control Ltd
Cleco Electric Ltd
Crompton Parkinson Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferguson Pailin Ltd
General Electric Co Ltd, The
Heywood & Co Ltd, S. H.
Ionic Instruments (London) Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Read & Partners Ltd
Savage & Parsons Ltd
Scott & Co, James
Sealey Engineering Co Ltd
Service Electric Co Ltd
Simon-Carves Ltd
Stabilag Co Ltd, The
Sullivan Ltd, H. W.

CONTRACTORS—Instrumentation
★ Circle **No 358** on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, N. G.
Bayley Clanahan Ltd (pyrometric)
Bryans Aeroquipment Ltd
Boulton Paul Aircraft Ltd
Brush Electrical Ltd
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Cleco Electrical Ltd
Constructors John Brown Ltd
Crosby Valve & Engineering Co Ltd
Dowty Nucleonics Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd (Instrument Division)
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Grabb Parsons & Co Ltd, Sir Howard
Hawker Siddeley Nuclear Power Co Ltd
Honeywell Controls Ltd
Hutchison Duthie & Co Ltd, R.
Integra, Leeds & Northrup, Ltd
Irwin & Partners Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
Ketay Ltd
Measurement Ltd
Mullard Equipment Ltd
Negretti & Zambra Ltd
New Western (Engineering) Ltd
Nuclear Enterprises (GB) Ltd
Parkinson & Cowan Ltd
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Sealey Engineering Co Ltd
Short Bros & Harland Ltd
Simon-Carves Ltd
Southern Instruments (Computer Division)
Sunvic Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Tinsley & Co Ltd, H.
Vickers-Armstrongs (a/c) Ltd
Weyers Bros Ltd

CONTRACTORS—mechanical engineering
★ Circle **No 359** on reply card
Andrews & Platt (Engineers) Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Bailey & Co Ltd, N. G.
Balfour, Beatty & Co Ltd
Blundell & Crompton Ltd
Birmingham & Blackburn Construction Co Ltd
British Electrical Repairs Ltd
Chamberlain Industries Ltd
Cleco Electrical Ltd
Constructors John Brown Ltd
Cravens Ltd
Curran Ltd, John
Davenport Engineering Co Ltd, The
Davidson & Co Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
E.R.D. Engineering Co Ltd
Evans & Son (Portsmouth) Ltd, J.
General Steel & Iron Ltd
Foster Wheeler Ltd
Hawker Siddeley Nuclear Power Ltd
Head Wrightson Processes Ltd
Head Wrightson Teesdale Ltd
Innes Ltd, J. K.
Ionic Instruments (London) Ltd
Liquid Systems Ltd
Miller Ltd, P. & J.
Mitchell Engineering Ltd
Moore Ltd, W. & E.
Morfax Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Paterson Hughes Engineering Co Ltd
Press & Son Ltd, W.
Rubery Owen Ltd (Darlaston)
Ryder & Co (Manchester) Ltd, Thomas
Savage & Parsons Ltd
Screw Machine Products Ltd (Machining)
Sealey Engineering Co Ltd
Simon-Carves Ltd
Stokes Taylor & Shaw Ltd
Sykes Ltd, Henry
Vickers-Armstrongs (a/c) Ltd
Ward Ltd, Thos W.
Wilson & Son Ltd, Edward

CONTRACTORS—nuclear power station
★ Circle **No 360** on reply card
AEI-John Thompson Nuclear Energy Co Ltd
Atomic Power Constructions Ltd
Babcock & Wilcox Ltd
English Electric Co Ltd, The
English Electric, Babcock & Wilcox and Taylor Woodrow Nuclear Energy Co Ltd
General Electric, Simon-Carves Group
Hawker-Siddeley Nuclear Power Ltd
Head Wrightson Ltd (NP Div) (with NPP Co)
Humphreys & Glasgow Ltd
Mitchell Engineering Ltd
Nuclear Power Plant Co Ltd
Ruston & Kier group

CONTRACTORS—pipework
★ Circle **No 361** on reply card
Aiton & Co Ltd
Ashmore, Benson, Pease & Co
Avica Equipment Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, N. G.
Birmingham & Blackburn Construction Co Ltd
Brightside Heating & Engineering Co Ltd
Capper & Co Ltd, William H.
Constructors John Brown Ltd
Dempster Ltd
Dowty Nucleonics Ltd
Extrudex Ltd
Foster Wheeler Ltd
General Steel Group
Head Wrightson Processes Ltd
Head Wrightson Teesdale Ltd
Hilmor Ltd (bending m/cs)
Horseley Bridge & Thomas Piggott Ltd
Humphreys & Glasgow Ltd
Jeffreys & Co Ltd, J.
Jenkins & Co Ltd, Robert
Kirk & Co (Tubes) Ltd
Lawrie Ltd, J. & T.
Liquid Systems Ltd
Low & Sons Ltd, Archibald
Marston Excelsior Ltd
Mendip (Chem. Eng.) Ltd
Metal & Pipeline Endurance Ltd
Metal Propellors Ltd
Mills Packard Construction Co Ltd
Millspaugh Ltd
Mitchell Engineering Ltd
Munro & Miller Ltd
Pipe Fabricators Ltd
Press & Son Ltd, William
QVF Ltd
Rubery Owen Ltd (Warrington)
Ryder & Co (Manchester) Ltd
Shaw-Petrie Ltd
Sheet Metal Engineering Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Steels Engineering Products Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
Tees-Side Bridge & Engineering Ltd
Thompson (Pipework) Ltd, John
Unit Superheater & Pipe Co Ltd
Vickers-Armstrongs (a/c) Ltd
Ward Ltd, Thos W.
Watson & Co Ltd, Robert

CONTRACTORS—welding
★ Circle **No 362** on reply card
Anglo Swedish Electric Welding Co Ltd
Ashmore, Benson, Pease & Co

CONTRACTORS—welding—*continued*
Barimar Ltd
Capper & Co Ltd, William H.
Chatwood-Milner Ltd
Cleco Electric Ltd
Deloro Stellite Ltd
Downey Ltd
Fairey Aviation Co Ltd, The
Farmer & Son Ltd
Ferguson & Robertson Ltd
Foster Wheeler Ltd
General Steel Group
Head Wrightson Teesdale Ltd
Horseley Bridge & Thomas Piggott Ltd
Invicta Electrodes Ltd
Merrill Pumps Ltd
Metal & Pipeline Endurance Ltd
Millspaugh Ltd
Moore & Co Ltd, W. & E.
Motherwell Bridge & Engineering Co Ltd
Murex Welding Processes Ltd
Napier & Son Ltd, D.
Press & Son Ltd, W.
Rockweld Ltd
Rubery Owen Ltd
Ryder & Co (Manchester) Ltd, Thos.
Rye-Arc Ltd
Shaw-Petrie Ltd
Sheet Metal Engineering Ltd
Simmons & Hawker Ltd
Stokes, Taylor & Shaw Ltd
Suffolk Iron Foundry (1920) Ltd
Vickers-Armstrongs (a/c) Ltd
Ward Ltd, Thos. W.
Welding Supervision Ltd
Yorkshire Engineering & Welding Co Ltd

CONTROL DRIVES—REACTOR
★ Circle **No 363** on reply card
British Thomson-Houston Co Ltd, The
Chatwood-Milner Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elliott Brothers (London) Ltd
Elliott Nucleonics Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Gordon & Co Ltd, James
Hawker Siddeley Nuclear Power Co Ltd
Hobson Ltd, H. M.
Kent Ltd, George
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Screw Machine Products Ltd, (components)
Sunvic Controls Ltd
Teleflex Products Ltd
Vickers-Armstrongs (a/c) Ltd

CONTROL RODS—REACTOR
★ Circle **No 364** on reply card
Accles & Pollock Ltd
Chatwood-Milner Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
Hadfields Ltd
Hawker Siddeley Nuclear Power Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Sunvic Controls Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

CONTROL SYSTEMS—REACTOR
★ Circle **No 365** on reply card
Appleby & Ireland Ltd
Ardleigh Engineering Ltd
Arens Controls Ltd
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
Ekco Electronics Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Fairey Aviation Co Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Hawker Siddeley Nuclear Power Co Ltd
Hobson Ltd, H. M.
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Metropolitan-Vickers Electrical Co Ltd
Mujrhead & Co Ltd
NGN Electrical Ltd
Plessey Nucleonics Ltd
Pye Ltd
Ramsey Engineering Co Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd
Sperry Gyroscope Co Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Vickers-Armstrongs (a/c) Ltd

CONVEYORS—BULK MATERIAL
★ Circle **No 366** on reply card
Aerox Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrews & Platt (Engineers) Ltd
Babcock & Wilcox Ltd
Birmingham & Blackburn Construction Co Ltd
Clarke, Chapman & Co Ltd
Distington Engineering Co Ltd
Fisher & Ludlow Ltd
General Electric Co Ltd, The
General Steel & Iron Ltd
Humphreys & Glasgow Ltd
Magnetic Equipment Co Ltd, The
Mitchell Engineering Ltd
Morris, Ltd
Parker Mitchell Engineering Co Ltd
Paterson Hughes Engineering Co Ltd
Rubery Owen Ltd (Darlaston)
Sheepbridge Engineering Ltd
Simon-Carves Ltd
Thompson Conveyor Co, John
Tilghman's Ltd
TI Nuclear Engineering Ltd
United Steel Companies Ltd, The
Wykeham Ltd

COOLERS—AIR *(See Air Coolers)*

COOLERS—OIL
★ Circle **No 367** on reply card
Birwelco Ltd
Brown Fintube (GB) Ltd
Dore Ltd
Empyrium Ltd
Farmer & Son Ltd
Head Wrightson Processes Ltd
Holmes Ltd
Newton, Chambers & Co Ltd
Premier Cooler & Engineering Co Ltd, The
Spiro-Gills Ltd
Superheater Co Ltd, The
Visco Engineering Co Ltd
Worthington-Simpson Ltd

COOLING TOWERS—NATURAL DRAUGHT
★ Circle **No 368** on reply card
Brotherhood Ltd, Peter
Cooling Towers Ltd
Davenport Engineering Co Ltd, The
Head Wrightson Processes Ltd
Mitchell Engineering Ltd
Premier Cooler & Engineering Co Ltd, The
Price, Charles R.
Visco Engineering Co Ltd

COOLING TOWERS—FORCED DRAUGHT
★ Circle **No 369** on reply card
Andrews & Platt Ltd
Brotherhood Ltd, Peter
Film Cooling Towers Ltd
Foster Wheeler Ltd
Head Wrightson Processes Ltd
Heenan & Froude Ltd
Premier Cooler & Engineering Co Ltd, The
Shaw Petrie Ltd
Visco Engineering Co Ltd
Worthington-Simpson Ltd

CORROSION PROTECTION
★ Circle **No 370** on reply card
Abril Corpn, (G.B.) Ltd
Albright & Wilson Ltd (nickel-phosphorous plating)
Berk & Co Ltd, F. W.—Schori Division (metal & plastic spray)
Birlec Ltd
Bitulac Ltd
Braby & Co Ltd, Fredr. (hot dip & galvanizing)
British Paints Ltd (paint)
British Refrasil Ltd (stainless steel sheet lining)
Cartwright Ltd
Cathodic Corrosion Control Ltd (cathodic)
Chrome-Alloying Co Ltd (metal diffn.)
CIBA (epoxy resin)
Constructors John Brown Ltd (Cathodic)
C. & P. Development Co, London, Ltd
Crane Packing Ltd
Crosfield & Sons Ltd, Joseph (chemical)
Detel Products Ltd (paint)
Electropol Processing Ltd (electropolishing)
Evode Ltd (paints)
Extrudex Ltd (plastic)
Garthwood Co Ltd (plastic)
Geigy Co Ltd (oils and inhibitors)
General Descaling Co Ltd
Green & Son Ltd, E.
Grey & Marten Ltd
Harvey Ltd, G. A. (galvanizing)
Hawker Siddeley Nuclear Power Ltd (metal, ceramic spray)
Houseman & Thompson (organic)
Leyland Paint & Varnish Co Ltd
Metal & Pipeline Endurance Ltd
Metallisation Ltd (metal spray)
Motherwell Bridge & Engineering Co Ltd, The (metal spray)
North British Chemical Co Ltd (paint)
Protective Coatings Ltd
Powell Duffryn Carbon Products Ltd
Rubery Owen Ltd
Shell Chemicals Ltd
Tees-Side Bridge & Engineering (H.D. Galv.)
Telegraph Construction & Maintenance Co Ltd, The (plastic coatings)
Toolchrome Ltd (hard chrome deposition)
Universal Boilers & Engineering Ltd (met spray)
Wallace & Tiernan Ltd

COUPLINGS—FLEXIBLE
★ Circle **No 371** on reply card
Armstrong-Whitworth (Met. Ind.) Ltd
Avica Equipment Ltd
Avimo Ltd
Bells Asbestos Ltd
British Thomson-Houston Co Ltd, The
Crofts (Engineers) Ltd
Electro-Hydraulics Ltd
Fenner & Co Ltd, J. H.
High Pressure Components Ltd
Metalastik Ltd
Precision Heating Ltd
Renold Chains Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sheepbridge Engineering
Silentbloc Ltd
TI Nuclear Engineering Ltd
Whittaker Hall & Co (1929) Ltd

COUPLINGS—HYDRAULIC
★ Circle **No 372** on reply card
Avica Equipment Ltd
British Ermeto Corporation Ltd
Chamberlain Industries Ltd
Crofts (Engineers) Ltd
Filton Ltd
Fluidrive Engineering Co Ltd
Guyson Industrial Equipment Ltd
High Pressure Components Ltd
IV Pressure Controllers Ltd
Lockheed Precision Products Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
TI Nuclear Engineering Ltd

COUPLINGS—PIPE
★ Circle **No 373** on reply card
Avica Equipment Ltd
Avimo Ltd
Bells Asbestos Ltd
British Ermeto Corporation Ltd
Capper & Co Ltd, William H.
Globe Pneumatic Eng Co Ltd
Guyson Industrial Equipment Ltd
High Pressure Components Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Lockheed Precision Products Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

CRANES
★ Circle **No 374** on reply card
Anderson-Grice Co Ltd
Andrews & Platt (Engineers) Ltd
ASEA Electric Ltd
Babcock & Wilcox Ltd
British Industrial Engineering Co (Staffs) Ltd
Butters Bros Ltd
Carruthers & Co Ltd
Caswell Cranes & Erection Ltd
Clarke, Chapman & Co Ltd
Clayton Crane & Hoist Co Ltd
Clyde Crane & Booth Ltd
Elliston, Evans & Jackson Ltd
Fellows Bros Ltd
Fowler & Co (Leeds) Ltd, John
General Steel & Iron Ltd
Henderson & Co Ltd, John M.
Heywood & Co Ltd, S. H.
K. & L. Steelfounders & Engineers Ltd
King Ltd, Geo. W.
Matterson Ltd
Mitchell Engineering Ltd
Morris Ltd, Herbert
Morrison, Marshall & Hill Ltd
Motherwell Bridge & Engineering Co Ltd, The
Neal & Co, R. H. (Mobile)
Newton, Chambers & Co Ltd
Paterson Hughes Engineering Co Ltd
Rubery Owen Ltd (Darlaston)
Steels Engineering Products Ltd
Strachan & Henshaw Ltd
Vaughan Crane Co Ltd, The
Ward Ltd, Thos. W.
Wharton Crane & Hoist Co Ltd, The

CRUCIBLES—INDUSTRIAL
★ Circle **No 375** on reply card
Baker Platinum Div, Engelhard Industries Ltd (platinum)
Bayley Clanahan Ltd
Carborundum Co Ltd, The (all types)
Fleischmann (London) Ltd (quartz)
Guest Industrials Ltd
Laboratory Apparatus & Glass Blowing Co
Morgan Crucible Co Ltd, The (all types)
Morgan Refractories Ltd (all types)
Powell Duffryn Carbon Products Ltd (carbon & graphite)
Scientific Furnishings Ltd
Thermal Syndicate Ltd, The (Vitreosil & refractory)

DEAERATORS
★ Circle **No 376** on reply card
Allen Sons & Co Ltd, W. H.
Boby & Co Ltd, William
Heat Transfer Ltd
Hick, Hargreaves & Co Ltd
Jenkins & Co Ltd, Robert
Motherwell Bridge & Engineering Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Newton, Chambers & Co Ltd
Richardsons, Westgarth & Co Ltd
Sheet Metal Engineering Ltd
Simon-Carves Ltd
Thompson Bros (Bilston) Ltd
Thompson-Kennicott Ltd, John
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

DEHUMIDIFICATION PLANT
★ Circle **No 377** on reply card
Air Control Installations Ltd
Andrew Machine Construction Co Ltd
Biddle Ltd, F. H.
Birlec Ltd
Burnett & Lewis Ltd
Cargocaire Ltd
Carrier Engineering Co Ltd
Crosfield & Sons Ltd, Joseph (silica gel)
Heat Transfer Ltd
Keith Blackman Ltd
Mancuna Engineering Co Ltd
Magnetic Equipment Co Ltd, The
Motherwell Bridge & Engineering Co Ltd, The
Peabody Ltd
Porter (Sales) Ltd, Alfred
Sturtevant Engineering Co Ltd
Thermocontrol Installations Co Ltd
Visco Engineering Co Ltd
Wykeham & Co Ltd, W.

DEMINERALIZATION PLANT
★ Circle **No 378** on reply card
Boby & Co Ltd, Wm.
Heat Transfer Ltd
Motherwell Bridge & Engineering Co Ltd, The
Neckar Water Softeners Ltd
Permutit Co Ltd, The
Thompson-Kennicott Ltd, John

DESUPERHEATERS
★ Circle **No 379** on reply card
Babcock & Wilcox Ltd
Chesterfield Tube Co Ltd, The
Copes Regulators Ltd
Dore Ltd
Foster Wheeler Ltd
Gordon & Co Ltd, James
Heat Exchangers Ltd
Heat Transfer Ltd
Hopkinsons Ltd
Jenkins & Co Ltd, Robert
Motherwell Bridge & Engineering Co Ltd, The
Simon-Carves Ltd
Superheater Co Ltd, The
Unit Superheater & Pipe Co Ltd

DIESEL POWER PLANT
★ Circle **No 380** on reply card
Allen Sons & Co Ltd, W. H.
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Crossley Bros Ltd
Davey, Paxman & Co Ltd
English Electric Co Ltd, The
Guest Industrials Ltd
Hamworthy Engineering Co Ltd (diesel-driven pumps)
Harland & Wolff Ltd
Hawker Siddeley Nuclear Power Co Ltd
Mirrlees, Bickerton & Day Ltd
Napier & Son Ltd, D.
Petbow Ltd
Ruston & Hornsby Ltd
Sykes Ltd, Henry
Wykeham Ltd

DISSOLVERS—FUEL ELEMENT
★ Circle **No 381** on reply card
Chesterfield Tube Co Ltd, The
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
Lang London Ltd
Nuclear Chemical Plant Ltd
QVF Ltd
Simon-Carves Ltd
Thompson (Wolverhampton) Ltd, John
TI Nuclear Engineering Ltd

DOORS—HEAVY SHIELDING
★ Circle **No 382** on reply card
Andrews & Platt (Engineers) Ltd
Chatwood-Milner Ltd
Farmer & Son Ltd
Fowler Ltd (lead)
General Steel Group
Grazebrook & Co Ltd, M. & W.
Haywards Ltd
Liquid Systems Ltd
Marine & Industrial Plastics Ltd
Peters Ltd, G. D.
Research & Control Instruments Ltd
Rye-Arc Ltd
Universal Boilers & Engineering Ltd
Vickers-Armstrongs (A/c) Ltd
Walker Ltd, C. & W.

DUCTWORK—FLEXIBLE
★ Circle **No 383** on reply card
Avica Equipment Ltd
Flexible Ducting Ltd
Keith Blackman Ltd
Motherwell Bridge & Engineering Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermotank Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Universal Boilers & Engineering Ltd

DUCTWORK—METALLIC
★ Circle **No 384** on reply card
Aerospray Associated Ltd
Air Control Installations Ltd
Airnesco Products Ltd
Allen & Sons (Tipton) Ltd, W. G.
Andrew Machine Construction Co Ltd, The
Avica Equipment Ltd
Babcock & Wilcox Ltd
Bawn & Co Ltd, W. B.
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr.
Brown & Co Ltd, E. G.
Bullows & Sons Ltd, Alfred
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Carricks & Sons Ltd
Cary Ltd, Wm. E.
Clarke, Chapman & Co Ltd
Controlled Heat & Air Ltd
Cornercroft Ltd
Dallow, Lambert & Co Ltd
Davidson & Co Ltd
Dore Ltd
Empyrium Ltd
Farmer & Son Ltd
Fowler Ltd (lead)
Freeman, Taylor Machines Ltd
Gardner & Co Ltd, J.
General Steel & Iron Co Ltd
Greenwoods & Airvac Ventilating Co Ltd
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Harvey Ltd, G. A.
Head Wrightson Teesdale Ltd
Howden & Co Ltd, James
Jeffreys & Co Ltd, J.
Jenkins & Co Ltd, Robert
Keith Blackman Ltd
Mancuna Engineering Ltd
Mills Packard Construction Co Ltd
Moore & Co Ltd, W. & E.
Morfax Ltd
Opperman Ltd, S. E.
Owen Power Plant Co
Ozonair Engineering Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pearson & Sons Ltd, T. B.
Prat-Daniel (Stanmore) Ltd
Premier Cooler & Engineering Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Scientific Furnishings Ltd
Sheet Metal Engineering Ltd
Southborough (Weybridge) Ltd
Stainless Steel Profile Cutters Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Stokes Taylor & Shaw Ltd
Taylor Rustless Fittings Ltd
Thermotank Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Tirfor Ltd
Tupholme & Co Ltd, George E.
Universal Boilers & Engineering Ltd
Visco Engineering Co Ltd, The
Walker & Co (Halifax) Ltd, P. M.
Watson & Co Ltd, Robert
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd
Wykeham & Co Ltd, W.

DUCTWORK—NON-METALLIC
★ Circle **No 385** on reply card
Air Control Installations Ltd
British Geon Ltd
BX Plastics Ltd
Dore Ltd
Doulton Industrial Porcelains Ltd
Extrudex Ltd
Flexible Ducting Ltd
Fowler Ltd (pvc)
Guest Industrials Ltd
Hathernware Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Mendip (Chemical Engineering) Ltd
QVF Ltd
Rediweld Ltd
Scientific Furnishings Ltd
Southborough (Weybridge) Ltd
Thermoplastics Ltd
Yarrow & Co Ltd

DUST COLLECTORS—CYCLONE
★ Circle **No 386** on reply card
Air Control Installations Ltd
Allen & Co Ltd, Edgar
Allen & Sons (Tipton) Ltd, W. G.
Andrew Machine Construction Co Ltd, The
Bennett Sons & Shears Ltd
Berk & Co Ltd, F. W.—Schori Division
Birmingham & Blackburn Construction Co Ltd
Blundell & Crompton Ltd
British CECA Ltd
Buell (1952) Ltd
Butterfield Ltd, W. P.
Carrier Engineering Co Ltd
Controlled Heat & Air Ltd
Dallow Lambert & Co Ltd
Davidson & Co Ltd
Gardner & Co Ltd, J.
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Head Wrightson Teesdale Ltd
Heat Transfer Ltd
Holmes & Co Ltd, W. C.
Howden & Co Ltd, James
Intermit Ltd
Keith Blackman Ltd
Mancuna Engineering Ltd
Mathews & Yates Ltd
Newton, Chambers & Co Ltd
Owen Power Plant Co
Ozonair Engineering Co Ltd
Power-Gas Corporation Ltd
Prat-Daniel (Stanmore) Ltd
Service Electric Co Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Vokes Ltd
Walker & Co (Halifax) Ltd, P. M.
Weatherfoil Heating Systems Ltd
Wykeham & Co Ltd, W.

DUST COLLECTORS—ELECTROSTATIC
★ Circle **No 387** on reply card
Aerospray Associated
Air Control Installations Ltd
Air-Maze Ltd
British CECA
Dempster Ltd
Fowler Ltd
Harris Engineering Co Ltd
Head Wrightson Teesdale Ltd
Holmes Ltd
Howden & Co Ltd, James
Keith Blackman Ltd
Midland Heating & Ventilation Co Ltd
Prat-Daniel (Stanmore) Ltd
Simon-Carves Ltd
South London Electrical Equipment Co Ltd
Sturtevant Engineering Co Ltd

EFFLUENT TREATMENT PLANT
★ Circle **No 388** on reply card
Aerox Ltd
Ancorite Ltd
APV Co Ltd
Barytes (Shielding Products) Ltd
Bennett Sons & Shears Ltd
Boby & Co Ltd, William
Candy Filter Co Ltd, The
Crosfield & Sons Ltd, Joseph
Davey Paxman Ltd
Dempster Ltd
Fraser & Co Ltd, W. J.
Fullers' Earth Union Ltd, The
Holmes Ltd
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Mendip (Chemical Engineering) Ltd
Newton, Chambers & Co Ltd
Nuclear Chemical Plant Ltd
Permutit Co Ltd, The
Plessey Nucleonics Ltd
QVF Ltd
Sharples Centrifuges Ltd
Simon-Carves Ltd
Thompson-Kennicott Ltd, John

EJECTORS—AIR
★ Circle **No 389** on reply card
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
English Electric Co Ltd, The
Foster Wheeler Ltd
Hathernware Ltd
Leybold Vacuum Sales Ltd
QVF Ltd
Powell Duffryn Carbon Products Ltd
Stanfield & Carver Ltd
Supervents Ltd
Weir Ltd, G. & J.
Western Detail Mfrs Ltd
Worthington-Simpson Ltd

ELECTRIC MOTORS—a.c.
★ Circle **No 390** on reply card
Allen Sons & Co Ltd, W. H.
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brook Motors Ltd
Brush Electrical Ltd
C.A.V. Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Electric Power Engineering Co (Birmingham)
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Evershed & Vignoles Ltd
Ferranti Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Greenwood & Batley Ltd
Harland Engineering Co Ltd
Harland & Wolff Ltd
Higgs Motors Ltd
Jones & Co (Engineers) Ltd, Walter
Kent Ltd, George
Ketay Ltd
Klaxon Ltd
Lancashire Dynamo & Crypto Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Leland Instruments Ltd
Mather & Platt Ltd
Metropolitan-Vickers Electrical Co Ltd
McKellan Automation Ltd
Muirhead & Co Ltd
Newman Industries Ltd
Plessey Nucleonics Ltd
Reyrolle & Co tLd, A.
Rotax Ltd
Scott & Co (Belfast) Ltd, Hugh J.
Stewart Aeronautical Ltd
Thermocontrol Installations Co Ltd
Ward Ltd, Thos W.

EVAPORATORS—CARBON DIOXIDE
★ Circle **No 391** on reply card
APV Co Ltd, The
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd
Distillers Co Ltd
Heat Transfer Ltd
Holmes Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd

EVAPORATORS—CHEMICAL
★ Circle **No 392** on reply card
Aiton & Co Ltd
Apex Construction Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Davey, Paxman & Co Ltd
Dore Ltd
Empyrium Ltd
Fraser & Co Ltd, W. J.
Giusti Ltd
Harvey Ltd, G. A.
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
Kestner Evaporator Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Nuclear Chemical Plant Ltd
QVF Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Thompson Bros. (Bilston) Ltd
Thompson (Dudley) Ltd, John
Worthington-Simpson Ltd

EVAPORATORS—POWER STATION
★ Circle **No 393** on reply card
Aiton & Co Ltd
Bennett Sons & Shears Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
English Electric Co Ltd, The
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
Richardsons, Westgarth & Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Simon-Carves Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wykeham Ltd

FANS
★ Circle **No 394** on reply card
Aeraspray Associated Ltd
Air Control Installations Ltd
Airscrew Co & Jicwood Ltd, The
A.K. Fans Ltd
Alldays & Onions Ltd
Andrew Machine Construction Co Ltd, The
Bryan Donkin Co Ltd, The
Bullows & Sons Ltd, Alfred
Davidson & Co Ltd
Extrudex Ltd
Fenton, Byrn & Co Ltd
General Electric Co Ltd, The
Green & Son Ltd, E.
Guest Industrials Ltd
Hathernware Ltd
Howden & Co Ltd, James
Jones & Stevens Ltd
Keith Blackman Ltd
Kestner Evaporator Ltd
Leland Instruments Ltd
Mathews & Yates Ltd
Midland Heating & Ventilation Co Ltd
Owen Power Plant Co
Plannair Ltd
Prat-Daniel Ltd
Rediweld Ltd
Revo Electric Ltd
Ruston & Hornsby Ltd
Scientific Furnishings Ltd
Service Electric Co Ltd
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Supervents Ltd
Thermotank Ltd
Vent-Axia Ltd
Walker & Co (Halifax) Ltd, P. M.
Walker Bros (Wigan) Ltd
Whittaker Hall & Co (1929) Ltd
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

FEED WATER HEATERS
★ Circle **No 395** on reply card
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Boby & Co Ltd, William
British Steam Specialties Ltd
Brown Fintube (GB) Ltd
Davey Paxman Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Green & Son Ltd, E.
Heat Exchangers Ltd
Heat Transfer Ltd
Metropolitan-Vickers Electrical Co Ltd
Newton, Chambers & Co Ltd
Nuclear Power Plant Co Ltd
Richardsons, Westgarth & Co Ltd
Simon-Carves Ltd
Spiro-Gills Ltd
Stanfield & Carver Ltd
Unit Superheater & Pipe Co Ltd, The
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

FILTERS—AIR (See Air Filters)

FILTERS—GAS
★ Circle **No 396** on reply card
Aerox Ltd
Air Control Installations Ltd
Air-Maze Ltd
Birfield Industries Ltd
British Filters Ltd
Callow (Engineers) Ltd, F. E.
Doulton Industrial Porcelains Ltd
Endecotts (Filters) Ltd
Fairey Aviation Co Ltd, The
Incandescent Heat Co Ltd
Innes & Co (Darlington) Ltd
Mancuna Engineering Ltd
Metal & Plastic Compacts Ltd
Marston Excelsior Ltd
Ozonair Engineering Co Ltd
Power-Gas Corporation Ltd
Sintered Products Ltd
Stream-Line Filters Ltd
Vokes Ltd

FILTERS—LIQUID METAL
★ Circle **No 397** on reply card
Aerox Ltd
Marston Excelsior Ltd
Metal & Plastic Components Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Press & Son Ltd, W.
Sintered Products Ltd

FILTERS—VACUUM
★ Circle **No 398** on reply card
Aerox Ltd
Air-Maze Ltd
Carlson Ltd, John C.
Davey, Paxman & Co Ltd
Dore Ltd
Doulton Industrial Porcelains Ltd
Edwards High Vacuum Ltd
Elmco (Great Britain) Ltd
Endecotts (Filters) Ltd
Extrudex Ltd
Fleischmann (London) Ltd
Fraser & Co Ltd, W. J.
Heat Transfer Ltd
International Construction Ltd
IV Pressure Controllers Ltd
Lacey-Hulbert & Co., Ltd
Leybold Vacuum Sales Ltd
Mendip (Chem. Eng.) Ltd
N.G.N. Electrical Ltd
Norgren Ltd, C. A.
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Sintered Products Ltd
Stream-Line Filters Ltd

FILTERS—WATER
★ Circle **No 399** on reply card
Aerox Ltd
Air-Maze Ltd
Ashworth & Parker Ltd
Auto-Kleen Strainers Ltd
Birfield Industries
Boby & Co Ltd, William
British Filters Ltd
British Steam Specialities Ltd
Calmic Engineering Co Ltd
Candy Filter Co Ltd, The
Carlson Ltd, John C.
Colborne Engineering Co Ltd, The
Davey, Paxman & Co Ltd
Dore Ltd
Doulton Industrial Porcelains Ltd
Endecotts (Filters) Ltd
Fairey Aviation Co Ltd, The
Glenfield & Kennedy Ltd
Gourock Ropework Ltd (cloths)
Heat Transfer Ltd
Hindle & Sons Ltd, Joshua (strainers)
Innes & Co (Darlington) Ltd
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Marston Excelsior Ltd
Metal & Plastic Compacts Ltd
Philips Electrical Ltd
Plenty & Son Ltd
Press & Son Ltd, W.
Pulsometer Engineering Co Ltd, The
Sheet Metal Engineering Ltd
Simmonds Aerocessories Ltd
Sintered Products Ltd
Thompson-Kennicott Ltd, John

FIRE FIGHTING EQUIPMENT
★ Circle **No 400** on reply card
Angus & Co Ltd, George
BTR Industries Ltd
Coventry Climax Engines Ltd
Fire Armour Ltd
Glenfield & Kennedy Ltd
Hindle & Sons Ltd, Joshua
Kidde Co Ltd, The Walter
Merryweather & Sons Ltd
Minerva Detector Co Ltd (detectors)
Minimax Ltd
National Fire Protection Co Ltd, The
Nu-Swift Ltd
Pyrene Co Ltd, The
RFD Co Ltd
Sigmund Pumps Ltd

FLEXIBLE PIPING & PIPE JOINTS (*See Pipes & Piping*)

FRICTION LININGS
★ Circle **No 401** on reply card
Ferodo Ltd

FUEL ELEMENT HANDLING EQUIPMENT
★ Circle **No 402** on reply card
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Chatwood-Milner Ltd
Cleco Electric Ltd (trucks)
Cravens Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
English Electric Co Ltd, The
Evans & Son (Portsmouth) Ltd, J.
Flight Refuelling Ltd
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson Processes Ltd
Horseley Bridge & Thomas Piggott Ltd (casings only)
Matterson Ltd
Mendip (Chem. Eng.) Ltd (non-metallic)
Monitor Patent Safety Devices Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Paterson Hughes Engineering Co Ltd
Savage & Parsons Ltd
Screw Machine Products Ltd (components)
Shandon Scientific Co Ltd
Spembly Ltd
Strachan & Henshaw, Ltd
Thompson Ordnance Co, John
Vickers-Armstrongs (a/c) Ltd
Western Detail Mfrs Ltd

FUEL ELEMENT MANUFACTURING PLANT
★ Circle **No 403** on reply card
Farmer Norton & Co Ltd, Sir James
Robertson & Co Ltd, W. H. A. (rod and tube extrusion)
TI Nuclear Engineering Ltd (rolling mill)

FUME HOODS
★ Circle **No 404** on reply card
Aeraspray Associated Ltd
Air Control Installations Ltd
Birmingham & Blackburn Construction Co Ltd
Bullows & Sons Ltd, Alfred
Butterfield Ltd, W. P.
Controlled Heat & Air Ltd
Cygnet Joinery Ltd
Dore Ltd
Extrudex Ltd
Fowler Ltd (lead, pvc)
Freeman, Taylor Machines Ltd
Griffin & George Ltd
Hargreaves & Sons Ltd, Henry
Hathernware Ltd
Keith Blackman Ltd
Kestner Evaporator Ltd
Marine & Industrial Plastics Ltd
Mathews & Yates Ltd
Mendip (Chemical Engineering) Ltd
Opperman Ltd, S. E.
Owen Power Plant Co
Ozonair Engineering Co Ltd
Permali Ltd
Press & Son Ltd, W.
Rediweld Ltd
Scientific Furnishings Ltd
Sturtevant Engineering Co Ltd
Supervents Ltd
Thermoplastics Ltd
Tilghman's Ltd
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Weatherfoil Heating Systems Ltd

FURNACES—ARC
★ Circle **No 405** on reply card
ASEA Electric Ltd
Bayley Clanahan Ltd
Birlec-Efco (Melting) Ltd
Fleischmann (London) Ltd
GWB Furnaces Ltd
Head Wrightson Processes Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—INDUCTION
★ Circle **No 406** on reply card
ASEA Electric Ltd
Bayley Clanahan Ltd
Birlec-Efco (Melting) Ltd
Delapena & Son Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Precision Heating Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—REDUCTION
★ Circle **No 407** on reply card
AEW Ltd
Barlow-Whitney Ltd
Bayley Clanahan Ltd
GWB Furnaces Ltd
Royce Electric Furnaces Ltd
Western Detail Mfrs Ltd

FURNACES—RESISTANCE
★ Circle **No 408** on reply card
AEW Ltd
Barlow-Whitney Ltd
Bayley Clanahan Ltd
Birlec Ltd
Catterson-Smith Ltd, R. M.
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Hoyt Metal Co of Great Britain Ltd, The
Incandescent Heat Co Ltd
Leybold Vacuum Sales Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Wild-Barfield Electric Furnaces Ltd

FURNACES—SINTERING
★ Circle **No 409** on reply card
AEW Ltd
Bayley Clanahan Ltd
Birlec Ltd
Catterson-Smith Ltd, R. M.
Fleischmann (London) Ltd
GWB Furnaces Ltd
Incandescent Heat Co Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

FURNACES—VACUUM
★ Circle **No 410** on reply card
AEW Ltd
Bayley Clanahan Ltd
Birlec Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
Hawker Siddeley Nuclear Power Co
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd
Royce Electric Furnaces Ltd
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

GAS CLEANING PLANT
★ Circle **No 411** on reply card
Aerox Ltd
Air Control Installations Ltd
British CECA Ltd
Dempster Ltd
Doulton Laboratory Porcelains Ltd
Engelhardt Ltd (Baker Platinum)
Fowler Ltd
Hawker Siddeley Nuclear Power Ltd (argon purifiers)
Head Wrightson Teesdale Ltd
Holmes Ltd
Howden & Co Ltd, James
Humphreys & Glasgow Ltd
Keith Blackman Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd
Mancuna Engineering Ltd
Newton, Chambers & Co Ltd
Power-Gas Corporation Ltd
Q.V.F. Ltd
Simon-Carves Ltd
Stanfield & Carver Ltd
Sturtevant Engineering Co Ltd

GAS CLEANING PLANT—*continued*
Walker Ltd, C. & W.
Western Detail Mfrs Ltd (argon purifiers)
Wykeham Ltd

GAS DRIERS
★ Circle **No 412** on reply card
British CECA Ltd
Dempster Ltd
Heat Transfer Ltd
Holmes Ltd
Incandescent Heat Co Ltd
Kestner Evaporator & Engineering Co Ltd
Lloyd & Ross Ltd
Magnetic Equipment Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
QVF Ltd
Silica Gel Ltd
Western Detail Mfrs Ltd

GAS STORAGE PLANT
★ Circle **No 413** on reply card
Butterfield Ltd, W. P.
Dempster Ltd
Empyrium Ltd
Lloyd & Ross Ltd
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd
Walker Ltd, C. & W.
Wykeham Ltd

GASES—ARGON
★ Circle **No 414** on reply card
British Oxygen Co Ltd, The
Imperial Chemical Industries Ltd
Saturn Oxygen Co Ltd

GASES—CARBON DIOXIDE
★ Circle **No 416** on reply card
Distillers Co Ltd
Imperial Chemical Industries Ltd
Research & Control Instruments Ltd (liquefiers)

GASES—HELIUM
★ Circle **No 417** on reply card
British Oxygen Co Ltd, The

GASES—HYDROGEN
★ Circle **No 418** on reply card
British Oxygen Co Ltd, The
Imperial Chemical Industries Ltd

GASES—NITROGEN
★ Circle **No 419** on reply card
British Oxygen Co Ltd, The
Research & Control Instruments Ltd (liquefiers)

GASES—OXYGEN
★ Circle **No 420** on reply card
British Oxygen Co Ltd, The
Research & Control Instruments Ltd (liquefiers)
Saturn Oxygen Co Ltd
Siebe, Gorman & Co Ltd

GASKETS—PRESSURE VESSEL & PIPE
★ Circle **No 421** on reply card
Beakbane Ltd, Henry
Bells Asbestos
BTR Industries Ltd
Clayton-Wright
Kirk & Co (Tubes) Ltd
Laboratory Apparatus & Glass Blowing Co
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Super Oil Seals & Gaskets Ltd
TI Nuclear Engineering Ltd
Turner Bros Asbestos Co Ltd
Walker & Co Ltd, James
Whitby & Chandler Ltd
Wood Bros & Co (Gaskets) Ltd

GEARING
★ Circle **No 422** on reply card
British Thomson-Houston Co Ltd, The
Brown Corporation Ltd, David
Crofts (Engineers) Ltd
Electropower Gears Ltd
Geartight Unions Ltd
Highfield Gear & Engineering Co Ltd
Meadows Ltd, Henry
Opperman Gears Ltd
Reliance Gear & Engineering Co (Salford) Ltd
Sanderson Bros & Newbould Ltd
Sealey Engineering Co Ltd
Servo Units Ltd
Varatio-Strateline Gears Ltd
Weyers Bros Ltd

GENERATORS—a.c.
★ Circle **No 423** on reply card
British Thomson-Houston Co Ltd, The
Brush Electrical Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Harland Engineering Co Ltd
Lancashire Dynamo & Crypto Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Meadows Ltd, Henry
Metropolitan-Vickers Electrical Co Ltd
Parsons & Co Ltd, C. A.
Rotax Ltd
Stewart Aeronautical Ltd
Sykes Ltd, Henry
Wykeham Ltd

GOVERNORS—TURBINE
★ Circle **No 424** on reply card
Ardleigh Engineering Ltd
Ashworth & Parker Ltd
British Thomson-Houston Co Ltd, The
Cockburns Ltd
Davey, Paxman & Co Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Parsons Ltd, C. A.
Rotax Ltd
Ruston & Hornsby Ltd

GRANULATORS
★ Circle **No 425** on reply card
Allen & Co Ltd, Edgar
Apex Construction Ltd
Burtonwood Ltd
Manesty Machines Ltd
Mansfield & Co Ltd, Frank

GRAPHITE—DISPERSIONS
★ Circle **No 426** on reply card
Acheson Colloids Ltd
British Acheson Electrodes Ltd
Centralube Ltd

GRAPHITE—MODERATOR
★ Circle **No 427** on reply card
Anglo Great Lakes Corporation Ltd
British Acheson Electrodes Ltd
English Electric Co Ltd, The
Morgan Crucible Co Ltd, The
New Metals & Chemicals Ltd
Nuclear Graphite Ltd
Powell Duffryn Carbon Products Ltd

GRAPHITE—REFLECTOR
★ Circle **No 428** on reply card
Anglo Great Lakes Corporation Ltd
British Acheson Electrodes Ltd
English Electric Co Ltd, The
Hawker Siddeley Nuclear Power Ltd (impregnated)
Nuclear Graphite Ltd
Powell Duffryn Carbon Products Ltd

GRINDING EQUIPMENT
★ Circle **No 429** on reply card
Anglo Abrasives Ltd
Flextol Engineering Co Ltd
Neill & Co (Sheffield) Ltd, James
Norton Grinding Wheel Co Ltd
Ross & Partners Ltd, Donald
Saturn Industrial Gases Ltd
Turret Grinding Wheel Co Ltd

HEAT EXCHANGERS—GAS/WATER
★ Circle **No 430** on reply card
Aerospray Associated Ltd
Aiton & Co Ltd
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Brown Fintube (GB) Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Delaney Gallay Ltd
Dempster Ltd
Dore Ltd
Empyrium Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Giusti Ltd
Green & Son Ltd, E.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Head Wrightson Teesdale Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Hunt Heat Exchangers Ltd
Holmes Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
International Combustion Ltd
Jenkins & Co Ltd, Robert
Johnstone (Engineers) Ltd, Archibald
Kestner Evaporator & Engineering Co Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Newton, Chambers & Co Ltd
QVF Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Spiro-Gills Ltd
Stainless Steel Vessels (London) Ltd
Stanfield & Carver Ltd
Superheater Co Ltd, The
Thompson Bros (Bilston) Ltd
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Towler Ltd
Unit Superheater & Pipe Co Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Wykeham Ltd

HEAT EXCHANGERS—METAL/METAL
★ Circle **No 431** on reply card
APV Co Ltd, The
Babcock & Wilcox Ltd
Birwelco Ltd
Brown Fintube (GB) Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Morgan Crucible Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Stainless Steel Vessels (London) Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd

HEAT EXCHANGERS—METAL/WATER
★ Circle **No 432** on reply card
APV Co Ltd, The
Babcock & Wilcox Ltd
Birwelco Ltd
Brown Fintube (GB) Ltd
Electro-Hydraulics Ltd
Fenton, Bryn & Co Ltd
Fleischmann (London) Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Marston Excelsior Ltd
Morgan Crucible Co Ltd, The
Newton, Chambers & Co Ltd
Revo Electric
Ryder & Co (Manchester) Ltd, Thomas
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Stainless Steel Vessels (London) Ltd
Standard & Pochin Bros Ltd, The
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Wellington Tube Works Ltd
Western Detail Mfrs Ltd

HEAT EXCHANGERS—WATER/WATER
★ Circle **No 433** on reply card
Aiton & Co Ltd
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Babcock & Wilcox Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Brown Fintube (GB) Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Clarke, Chapman & Co Ltd
Davey, Paxman & Co Ltd
Delaney Gallay Ltd
Dempster Ltd
Dore Ltd
Empyrium Ltd
Foster Wheeler Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Giusti Ltd
Green & Son Ltd, E.
Harvey Ltd, G. A.
Hawker Siddeley Nuclear Power Co Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Head Wrightson Teesdale Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Holmes Ltd
Horseley Bridge & Thomas Piggott Ltd
Hunt Heat Exchangers Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, Robert
Kestner Evaporator and Engineering Co Ltd
Marston Excelsior Ltd
Metal Propellers Ltd
Metropolitan-Vickers Electrical Co Ltd
Mills Packard Construction Co Ltd
Newton, Chambers & Co Ltd
QVF Ltd
Richardsons, Westgarth & Co Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Serck Radiators Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Spiral Tube & Components Co Ltd
Spiro-Gills Ltd
Superheater Co Ltd, The
Stanfield & Carver Ltd
Stainless Steel Vessels (London) Ltd
Thompson Bros (Bilston) Ltd
Thompson Water Tube Boilers Ltd, John
TI Nuclear Engineering Ltd
Towler Ltd
Weir Ltd, G. & J.
Wellington Tube Works Ltd
Western Detail Mfrs Ltd
Worthington-Simpson Ltd
Wykeham Ltd

HEATERS—PIPE
★ Circle **No 434** on reply card
APV Co Ltd, The
Backer Electrical Co Ltd (bolt heaters etc.)
Farmer & Son Ltd
Head Wrightson Processes Ltd
Isopad Ltd
Stabilag Co Ltd, The
Walker Ltd, C. & W.

HYDRAULIC CONTROL EQUIPMENT
★ Circle **No 435** on reply card
Avica Equipment Ltd
Baldwin Instrument Co Ltd
Boulton Paul Aircraft Ltd
Chamberlain Industries Ltd
Cleco Electric Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elliott Brothers (London) Ltd
Ellison Ltd, George
Evans & Son (Portsmouth) Ltd, J.
Exactor Ltd
Fairey Aviation Co Ltd, The
Fraser & Co Ltd, Andrew
Gordon & Co Ltd, James
Hamworthy Engineering Ltd
Hobson Ltd, H. M.
Hindle & Sons Ltd, Joshua
Integral Ltd
Keelavite Hydraulics Ltd

HYDRAULIC CONTROL EQUIPMENT *—continued*

Lockheed Precision Products Ltd
Martonair Ltd
Muirhead & Co Ltd
Plessey Co Ltd, The
Robey & Co Ltd
Sandall Precision Ltd
Stewart Aeronautical Ltd
Tangyes Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Vickers-Armstrongs (Engineers) Ltd
Weyers Bros Ltd

INSTRUMENTATION SYSTEMS *(See Contractors —Instrumentation)*

INSULATION—THERMAL
★ Circle **No 436** on reply card
Bayley Clanahan Ltd
Bells Asbestos Ltd
British Refrasil Ltd
BX Plastics Ltd
Cape Asbestos Co Ltd
Darlington Insulation Co Ltd, The
Delaney Gallay Ltd
Expanded Plastics Ltd
Extruded Ltd
Fibreglass Ltd
General Refractories Ltd
Hargreaves & Sons Ltd, Henry
Kenyon & Sons Ltd, Wm.
Kitson's Insulations Ltd
Lafarge Aluminous Cement Co Ltd
Leybold Vacuum Sales Ltd
Mallinson & Sons Ltd, William
Moler Products Ltd
Morgan Crucible Co Ltd, The
Morgan Refractories Ltd
Munro & Miller Ltd
Newalls Insulation Co Ltd
Northern Insulation Co (Stockton) Ltd
Onazote Insulation Co Ltd
Pilkington Bros Ltd
Simon-Carves Ltd
Stabilag Co Ltd
Stillite Products Ltd
Turner Bros Asbestos Co Ltd

INSURANCE & INSPECTION
★ Circle **No 437** on reply card
British Engine, Boiler & General Insurance Ltd
Lloyd's Register of Shipping (Land Division)
National Boiler & General Insurance Co Ltd, The
Vulcan Boiler & General Insurance Co Ltd

ION EXCHANGE PLANT
★ Circle **No 438** on reply card
Chatwood-Milner Ltd
Colborne Engineering Co Ltd, The
Crosfield & Sons Ltd, Joseph
Doby & Co Ltd, William
Griffin & George Ltd
Lennig Ltd (resins)
Neckar Water Softeners Ltd
Nuclear Chemical Plant Ltd
Permutit Co Ltd, The
QVF Ltd
Thompson-Kennicott Ltd, John

ISOTOPE PRODUCTION EQUIPMENT
★ Circle **No 439** on reply card
Hawker Siddeley Nuclear Power Ltd
Hobson Ltd, M.
Miles Hivolt Ltd
Nuclear Chemical Plant Ltd
Nuclear Engineering Ltd
QVF Ltd
Research & Control Instruments Ltd

LEAD
★ Circle **No 440** on reply card
(see also sec 2)
Appleton & Howard Ltd (castings)
Associated Lead Mfrs Ltd (all forms)
British Lead Mills Ltd (all forms)
Enthoven Ltd (all forms)
Fowler Ltd (all forms)
Grazebrook Ltd, M. & W. (linings)
Grey & Marten Ltd (Sheet, blocks)
Mills Packard Construction Co Ltd (blocks, fabrications of all types)
Podmore & Sons Ltd, W. (silicates & aluminates)
Research & Control Instruments Ltd (sheets, blocks)
Roberts Ltd, R. E.
Savage & Parsons Ltd (blocks)

LUBRICANTS
★ Circle **No 441** on reply card
Acheson Colloids Ltd
Midland Silicones Ltd
Paul (Molybdenum Disulphide) Ltd, K. S.
Rocol Ltd
Shell-Mex & BP Ltd
Wakefield-Dick Industrial Oils Ltd

LUBRICATION EQUIPMENT
★ Circle **No 442** on reply card
Centralube Ltd
Clarke, Chapman & Co Ltd
Liquid Systems Ltd
Norgren Ltd, C. A.
Sharples Centrifuges Ltd
Wakefield-Dick Industrial Oils Ltd
Vokes Ltd (Filters)

MACHINE TOOLS—FOR FUEL ELEMENT MFG
★ Circle **No 443** on reply card
Adam Machine Equipment Ltd
Adcock & Shipley Ltd
Bayley Clanahan Ltd (for ceramics)
Brooke Tool Ltd
Carne & Co Ltd, Rudolph
Colchester Lathe Ltd
Electro-Hydraulics Ltd
EMI Electronics Ltd
Evans & Son (Portsmouth) Ltd
Hardinge Machine Tools Ltd
Irwin & Partners Ltd
Rubery Owen Ltd (Darlaston)

MACHINE TOOLS—FOR GRAPHITE MFG
★ Circle **No 444** on reply card
Adcock & Shipley Ltd
Brooke Tool Ltd
Caine & Co Ltd, Rudolph
Colchester Lathe Ltd
Hardinge Machine Tools Ltd
Morrison, Marshall & Hill Ltd (Bandsaws)
Wadkin Ltd
Wicksteed & Co (1920) Ltd, Charles

METALS—ALUMINIUM
★ Circle **No 445** on reply card
Accles & Pollock Ltd (tubes)
Almin Ltd
APV Ltd (castings)
Berk & Co Ltd, F. W.—Schori Division (powder)
Birkett, Billington & Newton Ltd (castings)
Birmetals Ltd (sheet, tube, wire, rod, bar, sections)
Booth & Co Ltd, James
British Aluminium Co Ltd (all forms)
Ellay Tubes Ltd (tubes)
Eva Bros Ltd (forgings)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
High Duty Alloys Ltd
Horseley Bridge & Thomas Piggott Ltd
Imperial Chemical Industries Ltd (all forms)
Imperial Smelting Corporation (Sales) Ltd
Kaye Ltd, E. & E. (bar, tube, rod, wire, extruded sections)
London Aluminium Co Ltd
London Metal Warehouses Ltd (all forms)
Northern Aluminium Co Ltd (sheet, plate, sections, tube, wire, rod, castings, forgings)
Smith & Sons (Clerkenwell) Ltd, J. (bar, sheet, tube, rod)
Southern Forge Ltd
Sterling Metals Ltd
TI Nuclear Engineering Ltd (tube & sheet)

METALS—BERYLLIUM
★ Circle **No 446** on reply card
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
Imperial Chemical Industries Ltd
Imperial Smelting Corporation Ltd
Murex Ltd
New Metals & Chemicals Ltd
Telegraph Construction & Maintenance Co Ltd
TI Nuclear Engineering Ltd (tube)

METALS—BORON
★ Circle **No 447** on reply card
Acheson Colloids Ltd
Borax & Chemicals Ltd
Borax Consolidated Ltd
General Chemical & Pharmaceutical Co Ltd, The
Hadfields Ltd
New Metals & Chemicals Ltd (and compounds)
TI Nuclear Engineering Ltd (tube)

METALS—CADMIUM
★ Circle **No 448** on reply card
Consolidated Zinc Corp (Sales) Ltd (all forms)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd
Mining & Chemical Products Ltd

METALS—COPPER
★ Circle **No 449** on reply card
Berk & Co Ltd, F. W.—Schori Division (powder)
Birkett, Billington & Newton Ltd (castings)
Dore Ltd (sheet, tube)
Ellay Tubes Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Grey & Marten Ltd (tube, rod)
Imperial Chemical Industries Ltd (all forms)
Kaye Ltd, E. & E. (wire, strip)
London Metal Warehouses Ltd (all forms)
Mullard Ltd (wire)
Smith & Sons (Clerkenwell) Ltd, J. (bar, sheet, tube, rod)
Telegraph Construction & Maintenance Co Ltd

METALS—HAFNIUM
★ Circle **No 450** on reply card
Bramah & Co Ltd, J. R. (fabrications)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd
New Metals & Chemicals Ltd

METALS—LITHIUM
★ Circle **No 451** on reply card
Borax & Chemicals Ltd
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd
New Metals & Chemicals Ltd

METALS—MAGNESIUM
★ Circle **No 452** on reply card
Almin Ltd
Birmetals Ltd (sheet, tube, wire, rod, bar, sections)
Bramah & Co Ltd, J. R. (fabrications)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
High Duty Alloys Ltd
Imperial Chemical Industries Ltd
Magnesium Elektron Ltd
Sterling Metals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—MOLYBDENUM
★ Circle **No 453** on reply card
Accles & Pollock Ltd
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
Hadfields Ltd
Mullard Ltd (wire)
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—NICKEL
★ Circle **No 454** on reply card
Accles & Pollock Ltd
Eva Bros Ltd (forgings)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Hadfields Ltd
Horseley Bridge & Thomas Piggott Ltd
Mond Nickel Co Ltd, The
TI Nuclear Engineering Ltd (tube)

METALS—NIOBIUM
★ Circle **No 455** on reply card
Accles & Pollock Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd (all forms)
London & Scandinavian Metallurgical Co Ltd
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—STAINLESS STEEL
★ Circle **No 456** on reply card
Accles & Pollock Ltd (tubes)
Allen & Co Ltd, Edgar (bar & sheet)
APV Co Ltd, The (tubes)
Darwins Ltd
Dore Ltd
Eva Bros Ltd (forgings)
Firth-Vickers Stainless Steels Ltd
Fox & Co Ltd, Samuel
Hadfields Ltd
Hallamshire Steel Ltd (bar and rod)
Jessop & Sons Ltd, William
London Metal Warehouses Ltd
Low Moor Alloy Steelworks Ltd
Mountford (Birmingham) Ltd, Frederick
Oxley & Co Ltd, Wm. (castings, forgings, pipe flanges)
Sanderson Bros & Newbould Ltd
Stainless Steel Profile Cutters Ltd
Talbot Stead Tube Co Ltd (tubes & bars)
Taylor Stainless Metals Co Ltd (bar, sections, sheet, strip etc.)
TI Nuclear Engineering Ltd (tube)
United Steel Companies Ltd, The (sheets)

METALS—STEEL *(See Steel)*

METALS—TANTALUM
★ Circle **No 457** on reply card
Accles & Pollock Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
London & Scandinavian Metallurgical Co Ltd
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—THORIUM
★ Circle **No 458** on reply card
Borax & Chemicals Ltd
General Chemical & Pharmaceutical Co Ltd, The
New Metals & Chemicals Ltd
Rio Tinto Ltd (compounds)
Thorium Ltd
TI Nuclear Engineering Ltd (tube & bar)

METALS—TITANIUM
★ Circle **No 459** on reply card
Accles & Pollock Ltd (tubes)
Bramah & Co Ltd, J. R. (fabrications)
APV Co Ltd, The (pressings)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
High Duty Alloys Ltd
Imperial Chemical Industries Ltd (all forms)
Jessop & Sons Ltd, William
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)
Titanium Metal & Alloys Ltd

METALS—TUNGSTEN
★ Circle **No 460** on reply card
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
General Electric Co Ltd, The
Murex Ltd (bar, sheet, rod, wire, fabricated parts)

METALS—VANADIUM
★ Circle **No 461** on reply card
Accles & Pollock Ltd (tubes)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd
Magnesium Elektron Ltd
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)

METALS—ZIRCONIUM
★ Circle **No 462** on reply card
Accles & Pollock Ltd (tubes)
Bramah & Co Ltd, J. R. (fabrications)
Gardner & Co Ltd, Henry (all forms)
General Chemical & Pharmaceutical Co Ltd, The
Imperial Chemical Industries Ltd (all forms)
Jessop & Sons Ltd, William
Magnesium Elektron Ltd (salts)
Murex Ltd (bar, sheet, wire, rod, fabricated parts)
New Metals & Chemicals Ltd
TI Nuclear Engineering Ltd (tube)
Titanium Metal & Alloys Ltd

METALS—OTHERS
★ Circle **No 463** on reply card
Atkinson Ltd, D. & J. M. (mercury)
Berk & Co Ltd, F. W.—Schori Division (zinc powder)
Birkett, Billington & Newton Ltd (bronzes and h.d. iron)
Borax & Chemicals Ltd (rare earths)
Consolidated Zinc Corp (Sales) Ltd (zinc)
Deloro Stellite Ltd (cobalt & nickel base alloys)
Eva Bros Ltd (brass, bronze, nimonic forgings)
Fowler Ltd (leads)
Grey & Marten Ltd (tin, zinc)
Hadfields Ltd (boron alloy steels)
High Duty Alloys (aluminium & magnesium alloys)
Hill Ltd, C. L.

METALS—OTHERS—*continued*
Incandescent Heat Co Ltd (nickel-chrome alloys)
Kestner Evaporator & Engineering Co Ltd (silicon iron)
London & Scandinavian Metal Co Ltd (alloys of boron, titanium, niobium, tantalum)
Manganese Bronze & Brass Co Ltd, The
Metal & Plastic Compacts Ltd (ferro-boron alloys)
Rubery Owen Ltd (Darlaston)
Scientific Metal Co Ltd (mercury)
Sheffield Smelting Co Ltd, The (silver solders, brazing alloys)
Smith & Sons (Clerkenwell) Ltd, J. (brass, manganese-bronze, phosphor-bronze, aluminium alloys)
Southern Forge Ltd (aluminium alloys)
TI Nuclear Engineering Ltd (ferro-boron)
Willan Ltd, G. L.

MILLS—ORE REDUCING
★ Circle **No 464** on reply card
Allen & Co Ltd, Edgar
Apex Construction Ltd
Babcock & Wilcox Ltd
Boulton Ltd, Wm
Folisain-Wycliffe Foundries Ltd
General Electric Co Ltd, The
Head Wrightson Teesdale Ltd
Manesty Machines Ltd
Mansfield & Co Ltd, Frank
Sheepbridge Engineering Ltd
Sturtevant Engineering Co Ltd

MILLS—ROLLING
★ Circle **No 465** on reply card
Armstrong Whitworth (Met. Ind.) Ltd
Brockhouse & Co Ltd, J.
Bronx Engineering Co Ltd (plate bending)
Davey & United Engineering Co Ltd
Mann's Engineering Co Ltd, Albert
Marshall Richards Machine Co Ltd
Norton & Co Ltd, Sir James Farmer
Robertson & Co Ltd, W. H. A.
TI Nuclear Engineering Ltd

MIXER-SETTLERS—PULSE
★ Circle **No 466** on reply card
Lang London Ltd

MOUNTINGS—ANTI-VIBRATION
(see section 2)

NUCLEAR POWER STATIONS *(See Contractors—Nuclear Power Station)*

NUCLEAR REACTORS—*(See Reactors & Section 2)*

O-RINGS
★ Circle **No 467** on reply card
Angus & Co Ltd, George
British Ermeto Corporation Ltd
British Refrasil Ltd
BTR Industries Ltd
Dowty Seals Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Hindle & Sons Ltd, Joshua
Labgear Ltd
Leybold Vacuum Sales Ltd
Pioneer Oilsealing & Moulding Co Ltd
Precision Rubbers Ltd
Super Oil Seals & Gaskets Ltd
TI Nuclear Engineering Ltd
Trist & Co Ltd, Ronald
Vacuum Industrial Applications Ltd
Walker & Co Ltd, James

PACKINGS—GLAND
★ Circle **No 468** on reply card
Angus & Co Ltd, George
Beakbane Ltd, Henry
Bells Asbestos Ltd
BTR Industries Ltd
Engineering Appliances Ltd (Plastic)
Fleischmann (London) Ltd
Flexibox Ltd
Hindle & Sons Ltd, Joshua
Lorant & Co Ltd
TI Nuclear Engineering Ltd
Trist & Co Ltd, Ronald
Turner Bros Asbestos Co Ltd
United States Metallic Packing Co Ltd
Walker & Co Ltd, James
Wood Bros & Co (Gaskets) Ltd

PIPE COUPLINGS
★ Circle **No 469** on reply card
Avimo Ltd
Babcock & Wilcox Ltd
British Ermeto Corporation Ltd
British Refrasil Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Guyson Industrial Equipment Ltd
Hindle & Sons Ltd, Joshua
Kirk & Co (Tubes) Ltd
Leybold Vacuum Sales Ltd
Macnays Ltd
Mendip (Chem. Eng.) Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Screw Machine Products Ltd
Simmons & Hawker Ltd
Spembly Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Walker Ltd, C. & W.

PIPE EXPANSION JOINTS
★ Circle **No 470** on reply card
Aiton & Co Ltd
Avica Equipment Ltd (bellows)
Babcock & Wilcox Ltd (all types)
Bells Asbestos Ltd
Blundell & Crompton Ltd (bellows & sleeve)
British Steam Specialities Ltd (sliding type)
Capper & Co Ltd, William H. (bellows)
Crane Packing Ltd
Dore Ltd (loop, gland and bellows)
Engineering Appliances Ltd (bellows)
Extrudex Ltd
IV Pressure Controllers Ltd (bellows)
Jenkins & Co Ltd, Robert (all types)
Kirk & Co (Tubes) Ltd (all types)
MacLellan Ltd, G. (rubber)
Munro & Miller Ltd (bellows)
Nuclear Power Plant Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd (bellows)
Power Flexible Tubing Co Ltd, The (bellows)
Precision Heating Ltd (bellows)
Press & Son Ltd, W. (bends)
QVF Ltd (bellows)
Rye-Arc Ltd
Simmons & Hawker Ltd (bellows, gland, loop)
Shaw Glasgow Ltd
Shaw-Petrie Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd (all types)
Teddington Aircraft Controls Ltd (bellows)
TI Nuclear Engineering Ltd (bellows)
Unit Superheater & Pipe Co Ltd (bellows)
Universal Boilers & Engineering Ltd
Walker Ltd, C. & W.

PIPE FITTINGS—WELDING
★ Circle **No 471** on reply card
APV Ltd (stainless)
Babcock & Wilcox Ltd
Birkett, Billington & Newton Ltd
BKL Alloys Ltd
Blundell & Crompton Ltd
British Ermeto Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Compoflex Co Ltd
Guest Industrials Ltd
Harvey Ltd, G. A.
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkins & Co Ltd, F.
Imperial Chemical Industries Ltd
Kirk & Co (tubes) Ltd
Macnays Ltd
Munro & Miller Ltd
Osborne & Co Ltd, S.
Pipe Fabricators Ltd
Press & Son Ltd, William
Rediweld Ltd
Rubery Owen Ltd
Ryder & Co (Manchester) Ltd, Thomas
Shaw & McInnes Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Stainless Steel Profile Cutters Ltd
Stewarts & Lloyds Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
Taylor Rustless Fittings Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Universal Boilers & Engineering Ltd
Wellington Tube Works Ltd
Wilmot Breeden Ltd

PIPE FLANGES
★ Circle **No 472** on reply card
Babcock & Wilcox Ltd
Birkett, Billington & Newton Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Capper & Co Ltd, William H.
Freeman, Taylor Machines Ltd
General Steel & Iron Ltd
Harvey Ltd, G. A.
Hindle & Sons Ltd, J.
Kirk & Co (tubes) Ltd
Leybold Vacuum Sales Ltd
Marston Excelsior Ltd
Mendip (Chem. Eng.) Ltd. (non-metallic)
Oxley & Co Ltd, Wm. (stainless steel)
Pipe Fabricators Ltd
Precision Heating Ltd
Press & Son Ltd, William
Rediweld Ltd
Robertson & Ferguson Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simmons & Hawker Ltd
Stainless Steel Profile Cutters Ltd
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
Taylor Rustless Fittings Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Universal Boilers & Engineering Ltd
Walker Ltd, C. & W.

PIPE SUPPORTS
★ Circle **No 473** on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Industrial Engineering Co (Staffs) Ltd
British Steam Specialties Ltd
Capper & Co Ltd, William H.
Folisain-Wycliffe Foundries Ltd
Harvey & Co (London) Ltd, G. A.
Kirk & Co (tubes) Ltd
Motherwell Bridge & Engineering Co Ltd
Munro & Miller Ltd
Pipe Fabricators Ltd
Press & Son, Ltd, William
QVF Ltd
Robertson & Ferguson Ltd
Ryder & Co (Manchester) Ltd, Thos.
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Vokes Gensprings Ltd
Walker Ltd, C. & W.

PIPING—FLEXIBLE
★ Circle **No 474** on reply card
Abbofiex Ltd
Accles & Pollock Ltd
Avica Equipment Ltd
British Steam Specialities Ltd
BTR Industries Ltd
BX Plastics Ltd
Clay Cross (Iron & Foundries) Ltd
Compoflex Co Ltd
Dunlop Rubber Co Ltd
Hellerman Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
Lockheed Precision Products Ltd
Plessey Ltd
Power Flexible Tubing Co Ltd, The
Precision Heating Ltd
Shaw Glasgow Ltd
Shaw & McInnes Ltd
Smiths Industrial Instruments Ltd
Sykes Ltd, Henry
Teddington Aircraft Controls Ltd
TI Nuclear Engineering Ltd
Vicsons Ltd

PIPING—NON-FERROUS
★ Circle **No 475** on reply card
Abbofiex Ltd (bronze; brass)
Accles & Pollock Ltd
Birmingham Battery & Metal Ltd
Blundell & Crompton Ltd
Booth & Co Ltd, James
British Aluminium Co Ltd, The
British Ermeto Corporation Ltd (copper)
Caledonian Metal Co Ltd (copper; brass)
Compoflex Co Ltd
Costain-John Brown Ltd
Dore Ltd (copper)
Ellay Tubes Ltd (Brass, Copper, Aluminium & Light Alloys)
Fleischmann (London) Ltd
Fowler Ltd (lead)
Guest Industrials Ltd (lead lined)
Hawker Siddeley Nuclear Power Co Ltd
Imperial Chemical Industries Ltd
London Metal Warehouses Ltd
Marston Excelsior Ltd (aluminium)
Mills Packard Construction Co Ltd
Millspaugh Ltd
Munro & Miller Ltd (all types)
Northern Aluminium Co Ltd (aluminium)
Precision Heating Ltd (bronze)
Roberts Ltd, R. E. (lead, etc.)
Smith & Sons (Clerkenwell) Ltd, J. (brass, copper, aluminium & aluminium alloys)
Southern Forge Ltd (aluminium alloys)
Universal Boilers & Engineering Ltd
Wiggin & Co Ltd, Henry

PIPING—NON-METALLIC
★ Circle **No 476** on reply card
Abbofiex Ltd (plastic)
Avica Equipment Ltd (synthetic rubber)
British Ermeto Corporation Ltd (rubber)
British Geon Ltd
BX Plastics Ltd (plastic)
Compoflex Co Ltd
Doulton Industrial Porcelains Ltd (ceramic)
DuPont Ltd, Richard E.
Extrudex Ltd
Fowler Ltd (pvc)
Grey & Marten Ltd (plastic)
Hathernware Ltd (stoneware)
Imperial Chemical Industries Ltd
Kestner Evaporator & Engineering Co Ltd
Laboratory Apparatus & Glass Blowing Co
London Metal Warehouses Ltd
Mendip (Chemical Engineering) Ltd (Reinforced Plastic)
National Plastics Ltd (plastic)
QVF Ltd (glass)
Rediweld Ltd (plastic)
Stanton Ironworks (spun concrete)
Sykes Ltd, Henry (plastic)
Telegraph Construction & Maintenance Co Ltd, The (plastic)
Thermal Syndicate Ltd, The (vitreosil)
Thermo-Plastics Ltd (plastic)
TI Nuclear Engineering Ltd (plastic)
Vicsons Ltd

PIPING—STAINLESS STEEL
★ Circle **No 477** on reply card
Aiton & Co Ltd
Accles & Pollock Ltd
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Compoflex Co Ltd
Cravens Ltd
Dore Ltd
Foster Wheeler Ltd
Grey & Marten Ltd
Head Wrightson Teesdale Ltd
Horseley Bridge & Thomas Piggott Ltd
Incandescent Heat Co Ltd
Innes Ltd, J. E.
London Metal Warehouses Ltd
Kirk & Co (Tubes) Ltd
Macnays Ltd
Metal Propellers Ltd
Mills Packard Construction Co Ltd
Millspaugh Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Power Auxiliaries Ltd
Precision Heating Ltd
Press & Son Ltd, W.
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Stainless Steel Profile Cutters Ltd
Stainless Steel Vessels (London) Ltd
Talbot Stead Tube Co Ltd
Taylor Rustless Fittings Ltd
Taylor Stainless Metals Co Ltd
Thompson (Pipework) Ltd, John
TI Nuclear Engineering Ltd
Tube Investments Ltd
Tube Products Ltd (Weldless)
Unit Superheater & Pipe Co Ltd
Universal Boilers & Engineering Ltd

PIPING—STAINLESS STEEL—*continued*
Ward Ltd, Thos W.

PIPING—STEAM
★ Circle **No 478** on reply card
Aerospray Associated Ltd
Aiton & Co Ltd
Accles & Pollock Ltd
Allen & Sons (Tipton) Ltd, W. G.
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Compoflex Co Ltd
Grey & Marten Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Kirk & Co (Tubes) Ltd
Macnays Ltd
Munro & Miller Ltd
Pearson & Sons Ltd, T. B.
Press & Son Ltd, William
Power Auxiliaries Ltd
Shaw & McInnes Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Steels Engineering Installations Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Talbot Stead Tube Co Ltd
Thompson (Pipework) Ltd, John
TI Nuclear Engineering Ltd
Unit Superheater & Pipe Co Ltd
Universal Boilers & Engineering Ltd

PIPING—WATER
★ Circle **No 479** on reply card
Aerospray Associated Ltd
Aiton & Co Ltd
Accles & Pollock Ltd
Allen & Sons (Tipton) Ltd, W. G.
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialities Ltd
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Clay Cross (Iron & Foundries) Ltd
Compoflex Co Ltd
Extrudex Ltd
Foster Wheeler Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Horseley Bridge & Thomas Piggott Ltd
Imperial Chemical Industries Ltd
Kirk & Co (Tubes) Ltd
Macnays Ltd
Munro & Miller Ltd
Pearson & Sons Ltd, T. B.
Press & Son Ltd, William
Shaw & McInnes Ltd
Shaw Glasgow Ltd
Shaw-Petrie Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Stanton Ironworks
Staveley Iron & Chemical Co Ltd, The
Steels Engineering Installations Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Sykes Ltd, Henry
Talbot Stead Tube Co Ltd
Thompson (Pipework) Ltd, John
Unit Superheater & Pipe Co Ltd
Universal Boilers & Engineering Ltd
Vicsons Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos W.

PLASTICS
★ Circle **No 480** on reply card
Ayling Nuclear Equipment Co
Bakelite Ltd
Barytes (Shielding Products) Ltd
Bayley Clanahan Ltd
Berk & Co Ltd, F. W.—Schori Division
Bristol Aircraft Ltd
British Geon Ltd
Burtonwood Ltd (Machinery)
BX Plastics Ltd
Cartwright Ltd
Chemidus Plastics Ltd (corrosion resistant)
Clayton-Wright Ltd
Combined Optical Industries Ltd
Dale Ltd, John
DuPont, Richard E.
Expanded Plastics Ltd
Extrudex Ltd
Fairey Aviation Co Ltd, The
Fowler Ltd (pvc)
General Electric Co Ltd, The
Hellerman Ltd
Imperial Chemical Industries Ltd
Kestner Evaporator & Engineering Co Ltd
Laboratory Apparatus & Glass Blowing Co
Marine & Industrial Plastics Ltd
Measurement Ltd
Mendip (Chemical Engineering) Ltd
Monsanto Chemicals Ltd
National Plastics Ltd
Permali Ltd
Prodorite Ltd
Rediweld Ltd
Roberts Ltd, J. W.
Scientific Furnishings Ltd
Shell Chemical Co Ltd
Siemens Edison Swan Ltd
Southborough (Weybridge) Ltd
Spembly Ltd
Telegraph Construction & Maintenance Co Ltd
Thermo-Plastics Ltd
Vicsons Ltd
Whitby & Chandler Ltd

PNEUMATIC CONTROL EQUIPMENT
★ Circle **No 481** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evans & Son (Portsmouth) Ltd, J.
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Lang Pneumatic Ltd
Martonair Ltd
Negretti & Zambra Ltd
Rotax Ltd
Rubery Owen Ltd (Darlaston)
Sigma Instrument Co Ltd
Sunvic Controls Ltd
T.A.L. Numatics Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

POWDER METALLURGY PLANT
★ Circle **No 482** on reply card
Apex Construction Ltd
Cravens Ltd (Briquetting Presses)
Edwards High Vacuum Ltd
Leybold Vacuum Sales Ltd
Morton Machine Co Ltd

POWER TRANSMISSION EQUIPMENT
★ Circle **No 483** on reply card
British Thomson-Houston Co Ltd, The
Clayton-Wright Ltd
Crofts (Engineers) Ltd
Electropower Gears Ltd
Fenner & Co Ltd, J. H.
Renold Chains Ltd
Skefko Ball Bearing Co Ltd, The
Whittaker Hall & Co (1929) Ltd

PRECIPITATORS—ELECTROSTATIC (*See Dust Collectors*)

PRECIPITATORS—FISSION PRODUCT
(*see Gas Sampling Plant—sec. 2*)

PRESSURE VESSELS (*See Vessels—Pressure*)

PROCESS CONTROL EQUIPMENT
★ Circle **No 484** on reply card
Accurate Recording Instrument Co Ltd
AEW Ltd
Allied Electronics Ltd
Alto Instruments (GB) Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
British Thomson-Houston Co Ltd, The
Burndept Ltd
Cambridge Instrument Co Ltd
Chamberlain & Hookham Ltd
Crosby Valve & Engineering Co Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evans & Son (Portsmouth) Ltd, J.
Evershed & Vignoles Ltd
Fairey Aviation Co Ltd, The
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Heat Transfer Ltd
Honeywell-Brown Ltd
Humphreys & Glasgow Ltd
Hutcheon Duthie & Son Ltd, R.
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Jones & Stevens Ltd
Kent Ltd, George
Ketay Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
McKellan Automation Ltd
Measurement Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Equipment Ltd
Nagard Ltd
Negretti & Zambra Ltd
Newmark Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pye Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Rubery Owen Ltd (Darlaston)
Ruston & Hornsby Ltd
Salford Electrical Instruments Ltd
Screw Machine Products Ltd
Sealey Engineering Co Ltd
Sigma Instrument Co Ltd
Spembly Ltd
Sunvic Controls Ltd
T.A.L. Numatics Ltd
Taylor Controls Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Trist & Co Ltd, Ronald
Weyers Bros Ltd
Winston Electronics Ltd
Wright & Co Ltd, Alexander
Wykeham Ltd

PROTECTIVE CLOTHING
★ Circle **No 485** on reply card
Acetylene Generator & Tool Co Ltd
Andrews, Cuthbert
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
Bells Asbestos Ltd (chemical and heat)
British Industrial Gases Ltd
British Oxygen Gases Ltd
Fleming Ltd, J. & R.
Lincoln Electric Co Ltd (Welders)
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S. (leather, asbestos, pvc)
Murex Welding Processes Ltd
North & Sons Ltd, J.
Philips Electrical Ltd
Plysu Products Ltd
Quasi-Arc Ltd (Welders)
Safety Products Ltd
Siebe, Gorman & Co Ltd
Spembly Ltd (pvc suits)
Timeg Ltd
Turner Bros Asbestos Co Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

PUMPS (by type)

Rotodynamic—Axial flow
★ Circle **No 486** on reply card
Allen Sons & Co Ltd, W. H.
Armstrong Siddeley Motors Ltd
Budworth Ltd, David
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Ingersoll-Rand Ltd
Kestner Evaporator Ltd
K.S.B. Ltd
Pulsometer Engineering Co Ltd, The
Sigmund Pumps Ltd
Tangyes Ltd
Telehoist Ltd
Vickers-Armstrongs (Engineers) Ltd
Worthington-Simpson Ltd
Wykeham Ltd

Canned rotor
★ Circle **No 487** on reply card
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
K.S.B. Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Sealed Motor Construction Co
Sigmund Pumps Ltd
Sumo Pumps Ltd

Centrifugal (horizontal)
★ Circle **No 488** on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Autometric Pumps Ltd
Bell Precision Engineering Co Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd
Doulton Industrial Porcelains Ltd
Filton Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hathernware Ltd
Hayward Tyler & Co Ltd
Hick, Hargreaves & Co Ltd
Hughes & Lancaster Ltd
Ingersoll-Rand Ltd
Kestner Evaporator & Engineering Co Ltd
Lee, Howl & Co Ltd
Lyon & Co Ltd, Arthur
Mackley & Co Ltd, E. N.
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simm Engineering Ltd, G. E.
Sulzer Bros Ltd
Sykes Ltd, Henry
Tangyes Ltd
Ward Ltd, Thos W.
Wayne Tank & Pump Co Ltd
Weir Ltd, G. & J.
Wilkinson Rubber Linatex Ltd
Worthington-Simpson Ltd
Wykeham Ltd

Centrifugal (vertical)
★ Circle **No 489** on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Armstrong Siddeley Motors Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd (Glandless)
Budworth Ltd, David
Carruthers & Co Ltd, J. H.
Filton Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Ingersoll-Rand Ltd
Kestner Evaporator & Engineering Co Ltd
K.S.B. Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sulzer Bros Ltd
Sykes Ltd, Henry
Tangyes Ltd
Tubela Engineering Co Ltd
Ward Ltd, Thos. W.
Weir Ltd, G. & J.
Wilkinson Rubber Linatex Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd
Wykeham Ltd

Magnetic coupling
★ Circle **No 490** on reply card
Hydraulic & Mechanical Developments Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd

Mixed flow
★ Circle **No 491** on reply card
Allen Sons & Co Ltd, W. H.
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Ingersoll-Rand Ltd
K.S.B. Ltd
Pulsometer Engineering Co Ltd, The
Sigmund Pumps Ltd
Sulzer Bros Ltd
Sumo Pumps Ltd
Tangyes Ltd
Vickers-Armstrongs (Engineers) Ltd
Worthington-Simpson Ltd
Wykeham Ltd

PUMPS (by type)—*continued*

Multistage

★ Circle **No 492** on reply card

Berry Hill (Engineers) Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Hick, Hargreaves & Co Ltd
Holden & Brooke Ltd
Ingersoll-Rand Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Mackley & Co, E. N.
Pulsometer Engineering Co Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sulzer Bros Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wykeham Ltd

Self-priming

★ Circle **No 493** on reply card

Aeraspray Associated Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Carruthers & Co Ltd, J. H.
Coventry Climax Engines Ltd
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Ingersoll-Rand Ltd
Kestner Evaporator & Engineering Co Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd (contractors')
Saunders Valve Co Ltd
Sigmund Pumps Ltd
SPE Co Ltd
Sykes Ltd, Henry
Ward Ltd, Thos W.
Worthington-Simpson Ltd

Submerged motor

★ Circle **No 494** on reply card

Appleton & Howard Ltd
Bell Precision Engineering Co Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
K.S.B. Ltd
Palatine Tool & Engineering Co Ltd
Pulsometer Engineering Co Ltd
Sealed Motor Construction Co Ltd
Sumo Pumps Ltd
Worthington-Simpson Ltd
Wykeham Ltd

Water ring

★ Circle **No 495** on reply card

Autometric Pumps Ltd
Calmic Engineering Co Ltd
Coventry Climax Engines Ltd
Hamworthy Engineering Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Sigmund Pumps Ltd
Worthington-Simpson Ltd

Positive Displacement

Diaphragm

★ Circle **No 496** on reply card

Brackett & Co Ltd, F. W.
CT (London) Ltd
Distillers Co Ltd, The
Doulton Industrial Porcelains Ltd
ECD Ltd
Girdlestone Pumps Ltd
Guest Industrials Ltd
Kestner Evaporator Ltd
Johnson & Co Ltd, S. H.
Metering Pumps Ltd
Mitchell Ltd, L. A.
Pulsometer Engineering Co Ltd, The
Simm Engineering Ltd, G. E.
SPE Co Ltd
Sykes Ltd, Henry
Ward Ltd, Thos W.
Wilkinson Rubber Linatex Ltd
Wykeham Ltd

Gear or lobe

★ Circle **No 497** on reply card

Angus & Co Ltd, George
Autometric Pumps Ltd
BSA Tools Ltd
Freeman, Taylor Machines Ltd
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Holmes Ltd
Hydraulics & Pneumatics Ltd
Integral Ltd
Measurement Ltd
Northey Rotary Compressors Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Varley-FMC Ltd
Wade Engineering Ltd
Weyers Bros Ltd

Metering

★ Circle **No 498** on reply card

Distillers Co Ltd, The
ECD Ltd
Guest Industrials Ltd
Kingsbourne Products Ltd
Matterson Ltd
Metering Pumps Ltd
Ormerod Engineering Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Savery (Pumps), Ltd, Thomas
Telehoist Ltd
TI Nuclear Engineering Ltd
Wykeham Ltd

Reciprocating (sing. cyl.)

★ Circle **No 499** on reply card

Brackett & Co Ltd, F. W.
Clarke, Chapman & Co Ltd
ECD Ltd
Godwin Ltd, H. J.
Grease Appliance Co Ltd
Johnson & Co Ltd, S. H.
Kingsbourne Products Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Mackley & Co, E. N.
Matterson Ltd
Merrill Pumps Ltd
Metering Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd
Sykes Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

Reciprocating (multi. cyl.)

★ Circle **No 500** on reply card

Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.
Clarke, Chapman & Co Ltd
Carruthers & Co Ltd, J. H.
ECD Ltd
Godwin Ltd, H. J.
Hayward Tyler & Co Ltd
Hydraulics & Pneumatics Ltd
Johnson & Co Ltd, S. H.
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Lloyd & Ross Ltd
Mackley & Co, E. N.
Matterson Ltd
Metering Pumps Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Spenborough Engineering Co Ltd
Sykes Ltd, Henry
Tangyes Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
Tubela Engineering Co Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd

Screw or helix

★ Circle **No 501** on reply card

Hamworthy Engineering Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Mirrlees (Engineers) Ltd
Mono Pumps Ltd
Pulsometer Engineering Co Ltd, The
Telehoist Ltd
Varley-FMC Ltd

Vane

★ Circle **No 502** on reply card

Kestner Evaporators & Engineering Co Ltd
Lacy-Hulbert & Co Ltd (Air)
Liquid Systems Ltd
Plenty & Son Ltd
Sandall Precision Ltd
Spenborough Engineering Co Ltd
Stein Atkinson Vickers Hydraulics Ltd
Weyers Bros Ltd
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd

Variable delivery

★ Circle **No 503** on reply card

Ashwell & Nesbit Ltd
Distillers Co Ltd, The
Houseman & Thompson Ltd (dosage units)
Hydraulics & Pneumatics Ltd
Integral Ltd
Kingsbourne Products Ltd
Lee, Howl & Co Ltd
Matterson Ltd
Measurement Ltd
Metering Pumps Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Savery Pumps Ltd, Thomas
Tangyes Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
Tubela Engineering Co Ltd
Vickers-Armstrongs (Engineers) Ltd
Williams & James (Engineers) Ltd

Electromagnetic

★ Circle **No 504** on reply card

a.c. conduction
British Thomson-Houston Co Ltd, The
Palatine Tool & Engineering Co Ltd, The

d.c. conduction
British Thomson-Houston Co Ltd, The

a.c. induction, flat linear
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd

a.c. induction, annular linear
British Thomson-Houston Co Ltd, The

a.c. induction, rotating magnet
British Thomson-Houston Co Ltd, The

a.c. induction, spiral
English Electric Co Ltd, The

PUMPS (by purpose)

Acids

★ Circle **No 505** on reply card

Appleton & Howard Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Clarke, Chapman & Co Ltd
CT (London) Ltd
Distillers Co Ltd, The
Doulton Industrial Porcelains Ltd
ECD Ltd
Extrudex Ltd
Freeman, Taylor Machines Ltd
Guest Industrials Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Harris (Birmingham) Ltd, F. & R. M.
Hathernware Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Johnson & Co Ltd, S. H.
Kestner Evaporator & Engineering Co Ltd
K.S.B. Ltd
Leeds Engineering & Hydraulic Co Ltd
Merrill Pumps Ltd
Metering Pumps Ltd
Mono Pumps Ltd
Ormerod Engineers Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Redlweld Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
TI Nuclear Engineering Ltd
Watson-Marlow Air Pump Co
Wilkinson Rubber Linatex Ltd
Worthington-Simpson Ltd

Alkalis

★ Circle **No 506** on reply card

Appleton & Howard Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
BSA Tools Ltd
Clarke, Chapman & Co Ltd
CT (London) tLd
Distillers Co Ltd, The
ECD Ltd
Extrudex Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hathernware Ltd
Hayward Tyler & Co Ltd
Kestner Evaporator & Engineering Co Ltd
KSB Ltd
Lee, Howl & Co Ltd
Liquid Systems Ltd
Lloyd & Ross Ltd
Merrill Pumps Ltd
Metering Pumps Ltd
Mono Pumps Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Redlweld Ltd
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Weir Ltd, G. & J.
Wilkinson Rubber Linatex Ltd
Worthington-Simpson Ltd

Boiler circulator

★ Circle **No 507** on reply card

Allen Sons & Co Ltd, W. H.
Appleton & Howard Ltd
British LaBour Pumps Ltd
Carruthers & Co Ltd, J. H.
Clarke, Chapman & Co Ltd
CT (London) Ltd
Gilkes & Gordon Ltd, Gilbert
Girdlestone Pumps Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Ingersoll-Rand Ltd
Kestner Evaporator & Engineering Co Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simon-Carves Ltd
Sulzer Bros Ltd
Sykes Ltd, Henry
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wrights Electric Motors (Halifax) Ltd

Boiler feed

★ Circle **No 508** on reply card

Autometric Pumps Ltd
Berry Hill (Engineers) Ltd
Clarke, Chapman & Co Ltd
Gilkes & Gordon Ltd, Gilbert
Godwin Ltd, H. J.
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Ingersoll-Rand Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mono Pumps Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Simon-Carves Ltd
Sulzer Bros Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd
Wright Electric Motors (Halifax) Ltd
Wykeham Ltd

Cold water

★ Circle **No 509** on reply card

Aeraspray Associated Ltd
Allen Sons & Co Ltd, W. H.

PUMPS (by purpose)—*continued*
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd
Bailey & Co Ltd, Sir W. H.
Berry Hill (Engineers) Ltd
Brackett & Co Ltd, F. W.
British LaBour Pump Co Ltd
British Steam Specialties Ltd
BSA Tools Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
Freeman, Taylor Machines Ltd
Gilkes & Gordon Ltd, Gilbert
Globe Pneumatic Eng Co Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Ingersoll-Rand Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Liquid Systems Ltd
Lyon & Co Ltd, Arthur
Mackley & Co, E. N.
Madan & Co Ltd, Charles S.
Mono Pumps Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Rhodes, Brydon & Youatt Ltd
Ruston & Hornsby Ltd
Saunders Valve Co Ltd
Sealed Motor Construction Co Ltd
Sigmund Pumps Ltd
Sulzer Bros Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Trinity Pumps Ltd
Varley-FMC Ltd
Vickers-Armstrongs (Engineers) Ltd
Watson-Marlow Air Pumps Co
Weir Ltd, G. & J.
Williams & James (Engineers) Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd
Wrights Electric Motors (Halifax) Ltd
Wykeham Ltd

Condensate extraction
★ Circle **No 510** on reply card
Appleton & Howard Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Clarke, Chapman & Co Ltd
CT (London) Ltd
Girdlestone Pumps Ltd
Hamworthy Engineering Ltd
Ingersoll Rand Ltd
Kingsbourne Products Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Liquid Systems Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Tangyes Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wykeham Ltd

Heavy water
★ Circle **No 511** on reply card
Appleton & Howard Ltd
British LaBour Pump Co Ltd
CT (London) Ltd
ECD Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Hydraulic & Mechanical Developments Ltd
Lee, Howl & Co Ltd
Merrill Pumps Ltd
Plenty & Son Ltd
Sigmund Pumps Ltd
Watson-Marlow Air Pump Co
Wykeham Ltd

Liquid metals (electromagnetic)
★ Circle **No 512** on reply card
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd

Liquid metals (mechanical)
★ Circle **No 513** on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Bell Precision Engineering Co Ltd
British Thomson-Houston Co Ltd, The
ECD Ltd
Hayward Tyler & Co Ltd
Metering Pumps Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd

Oils
★ Circle **No 514** on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd
British LaBour Pump Co Ltd
BSA Tools Ltd
Burtonwood Ltd
Candy Filter Co Ltd, The
Carruthers & Co Ltd, J. H.
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
ECD Ltd
Fielding & Platt Ltd
Freeman, Taylor Machines Ltd
Grease Appliance Co Ltd
Gwynnes Pumps Ltd
Hamworthy Engineering Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hydraulics & Pneumatics Ltd
Integral Ltd
Keelavite Hydraulics Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Measurement Ltd
Metering Pumps Ltd
Mirrlees Ltd
Mono Pumps Ltd
Ormerod Engineers Ltd
Parkinson & Cowan Ltd
Plenty & Son Ltd
Pulsometer Engineering Co Ltd, The
Rhodes, Brydon & Youatt Ltd
Savery Pumps Ltd, Thomas
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Stein Atkinson Vickers Hydraulics Ltd
Tangyes Ltd
Telehoist Ltd
Tecalemit Ltd
Varley-FMC Ltd
Wakefield-Dick Industrial Oils Ltd
Watson-Marlow Air Pump Co
Wayne Tank & Pump Co Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd

Organic fluids
★ Circle **No 515** on reply card
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
British LaBour Pump Co Ltd
Clarke, Chapman & Co Ltd
Distillers Co Ltd, The
ECD Ltd
Freeman, Taylor Machines Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Houseman & Thompson Ltd (water treatment)
K.S.B. Ltd
Lee, Howl & Co Ltd
Measurement Ltd
Metering Pumps Ltd
Mono Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd, The
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Watson-Marlow Air Pump Co

Sea water
★ Circle **No 516** on reply card
Allen Sons & Co Ltd, W. H.
Appleton & Howard Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Autometric Pumps Ltd
Berry Hill (Engineers) Ltd
British LaBour Pump Co Ltd
Budworth Ltd, David
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd
Coventry Climax Engines Ltd
CT (London) Ltd
Gilkes & Gordon Ltd, Gilbert
Girdlestone Pumps Ltd
Godwin Ltd, H. J.
Gwynnes Pumps Ltd
Hamworthy Engineering Co Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Ingersoll-Rand Ltd
Kesiner Evaporator & Engineering Co Ltd
Kingsbourne Products Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Liquid Systems Ltd
Mackley & Co, E. N.
Mono Pumps Ltd
Ormerod Engineers Ltd
Pulsometer Engineering Co Ltd, The
Ruston & Hornsby Ltd
Ransomes & Rapier Ltd
Rhodes, Brydon & Youatt Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Sulzer Bros Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Vickers-Armstrongs (Engineers) Ltd
Weir Ltd, G. & J.
Worthington-Simpson Ltd
Wykeham Ltd

Semi-solids
★ Circle **No 517** on reply card
Appleton & Howard Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Brackett & Co Ltd, F. W.
British Steam Specialities Ltd
Centralube Ltd
Clarke, Chapman & Co Ltd
ECD Ltd
Globe Pneumatic Eng Co Ltd
Godwin Ltd, H. J.
Guest Industrials Ltd
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Johnson & Co Ltd, S. H.
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mackley & Co, E. N.
Madan & Co Ltd, Charles S.
Metering Pumps Ltd
Mono Pumps Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Sigmund Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Watson-Marlow Air Pump Co
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd

Slurry
★ Circle **No 518** on reply card
Allen & Co Ltd, Edgar
Appleton & Howard Ltd
Armstrong Siddeley Motors Ltd
Brackett & Co Ltd, F. W.
British LaBour Pump Co Ltd
BSA Tools Ltd
Cellulose Development Corporation Ltd
Clarke, Chapman & Co Ltd
Consolidated Pneumatic Tool Co Ltd, The
ECD Ltd
General Electric Co Ltd, The
Gwynnes Pumps Ltd
Harland Engineering Co Ltd
Hayward Tyler & Co Ltd
Holden & Brooke Ltd
Hughes & Lancaster Ltd
Johnson & Co Ltd, S. H.
Kestner Evaporator & Engineering Co Ltd
Kingsbourne Products Ltd
K.S.B. Ltd
Lee, Howl & Co Ltd
Leeds Engineering & Hydraulic Co Ltd, The
Mackley & Co Ltd, E. N.
Measurement Ltd
Merrill Pumps Ltd
Metering Pumps Ltd
Mono Pumps Ltd
Parkinson & Cowan Ltd
Pulsometer Engineering Co Ltd, The
Ransomes & Rapier Ltd
Saunders Valve Co Ltd
Sigmund Pumps Ltd
Spembly Ltd
Sumo Pumps Ltd
Sykes Ltd, Henry
Tangyes Ltd
Varley-FMC Ltd
Watson-Marlow Air pump Co, The
Wilkinson Rubber Linatex Ltd
Wilson & Son Ltd, Edward
Worthington-Simpson Ltd
Wykeham Ltd

Vacuum (*see Sec. 2*)

PURIFIERS—OIL
★ Circle **No 519** on reply card
Philips Electrical Ltd
Sharples Centrifuges Ltd
Stream-Line Filters Ltd

RADIOGRAPHIC SERVICES—INDUSTRIAL
★ Circle **No 520** on reply card
Arc Mfg Co Ltd
Ashmore, Benson, Pease & Co
BTR Industries Ltd
Butterfield Ltd, W. P.
Falk & Co Ltd, M.
Gamma-Rays Ltd
Gammax Ltd
Glass Developments Ltd
Industrial Radiography (NDT) Ltd
Inspection Services Ltd
Metropolitan-Vickers Electrical Co Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
Nuclear Engineering Ltd
Palmer Aero Products Ltd
Pantak Ltd
Towler Ltd
Unit Superheater & Pipe Co Ltd
Vickers-Armstrongs (a/c) Ltd
Welding Supervision Ltd
Western Detail Mfrs Ltd

REACTORS, NUCLEAR—BOILING WATER
★ Circle **No 521** on reply card
AEI-John Thompson Nuclear Energy Co Ltd
Mitchell Engineering Ltd
Nuclear Power Plant Co Ltd, The

REACTORS, NUCLEAR—GAS-COOLED
★ Circle **No 522** on reply card
AEI-John Thompson Nuclear Energy Co Ltd
Atomic Power Constructions Ltd
Babcock & Wilcox Ltd
de Havilland (high temperature)
English Electric Co Ltd, The
General Electric Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Nuclear Power Plant Co Ltd, The

REACTORS, NUCLEAR—HEAVY WATER MODERATED
★ Circle **No 523** on reply card
Vickers Armstrongs (a/c) Ltd (steam-cooled)

REACTORS, NUCLEAR—ORGANIC MODERATED
★ Circle **No 524** on reply card
English Electric Co Ltd
Hawker Siddeley Nuclear Power Co Ltd

REACTORS, NUCLEAR—PRESSURIZED WATER
★ Circle **No 525** on reply card
Babcock & Wilcox Ltd
Humphreys & Glasgow Ltd

REACTORS NUCLEAR—RESEARCH
(*See Section 2*)

REFLUX DIVIDERS
★ Circle **No 526** on reply card
Dore Ltd
Holmes Ltd
Metal Propellers Ltd
QVF Ltd

REFRACTORIES
★ Circle **No 527** on reply card
Bayley Clanahan Ltd
Carborundum Co Ltd, The
Castle Fire Brick Co Ltd, The
Curtis & Co, A. L.
English Clays, Lovering Pochin & Co Ltd
General Refractories Ltd
Hydronyl Syndicate Ltd
Lafarge Aluminous Cement Co Ltd
Morgan Refractories Ltd
New Metals & Chemicals Ltd
Podmore & Sons Ltd, W.
Prodorite Ltd
Simon-Carves Ltd
Thermal Syndicate Ltd, The

REFRIGERATION PLANT
★ Circle **No 528** on reply card
Brotherhood Ltd, Peter
Carrier Engineering Co Ltd
Heat Transfer Ltd
Lightfoot Refrigeration Co Ltd, The
Perfection Parts Ltd
Research & Control Instruments Ltd
Western Detail Mfrs Ltd

REGULATORS—FEED WATER
★ Circle **No 529** on reply card
Copes Regulators Ltd
Gordon & Co Ltd, James
Taylor Controls Ltd
Trist & Co Ltd, Ronald
Weir Ltd, G. & J.

SAND & SHOT BLASTING EQUIPMENT
★ Circle **No 530** on reply card
Airnesco Products Ltd (Sand Blasting)
Berk & Co Ltd, F. W.—Schori Division (both types)
BTR Industries Ltd (both types)
Curtis & Co, A. L. (both types)
Eutectic Welding Alloys Ltd
Guyson Industrial Equipment Ltd (both types)
Jackman & Co Ltd, J. W.
Metallising Equipment Co Ltd
Rubery Owen Ltd (both)
Vacu-Blast Ltd

SEALS—MECHANICAL SHAFT
★ Circle **No 531** on reply card
Angus & Co Ltd, George
Armstrong Whitworth (Met. Ind.) Ltd
Avica Equipment Ltd
Baker & Sons (Sales) Ltd, P. W.
Babcock & Wilcox Ltd
Burtonwood Ltd
Callow (Engineers) Ltd, F. E.
Crane Packing Ltd
Filton Ltd
Flexibox Ltd
General Electric Co Ltd, The
Morgan Crucible Co Ltd, The
Palatine Tool & Engineering Co (Surbiton) Ltd
Pioneer Oilsealing & Moulding Co Ltd
Powell Duffryn Carbon Products Ltd
Precision Rubbers Ltd (silicone rubber)
Super Oil Seals & Gaskets Ltd
Trist & Co Ltd, Ronald
Tube Investments Ltd
United States Metallic Packing Co Ltd
Whitby & Chandler Ltd
Wykeham Ltd

SEPARATORS—STEAM
★ Circle **No 532** on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
Blundell & Crompton Ltd
British Steam Specialities Ltd
Cockburns Ltd
Foster Wheeler Ltd
Gordon & Co Ltd, James
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Stokes Taylor & Shaw Ltd
Superheater Co Ltd, The
United States Metallic Packing Co Ltd

SHIELDING—BIOLOGICAL
★ Circle **No 533** on reply card
Andrews, Cuthbert (Lead Lined)
Barytes (Shielding Products) Ltd
British Lead Mills Ltd (lead)
Cairns & Co Ltd, John J. (barytes aggregates)
Chatwood-Milner Ltd (Lead)
Cornwall Mills Ltd (Barytes)
Enthoven Ltd (lead)
Fowler Ltd (lead)
General Electric Co Ltd (heavy alloy)
General Metal Utilisation (lead)
General Radiological Ltd (Fabricated)
Grazebrook Ltd, M. & W.
Hull Ltd, P.
International Mechanite Metal Co Ltd, The
Isotope Developments Ltd
Mallinson Ltd, W.
Mears Bros Ltd
Mills Packard Construction Co Ltd (Lead)
Mitchell Engineering Ltd (Concrete)
Newton Victor Ltd (Lead)
Nuclear Engineering Ltd
Optical Works Ltd
Permali Ltd
Pilkington Bros Ltd
Price, Charles R. (Concrete)
QVF Ltd (Glass)
Randall Ltd, P. E. (lead)
Rediweld Ltd (Plastics)
Research & Control Instruments Ltd (concrete, lead)
Roberts Ltd, R. E. (lead)
Savage & Parsons Ltd (Concrete, Lead)
Simon-Carves Ltd (Concrete)
Soole Ltd (lead, barytes)
Towler Ltd (lead)
United Chemicals (London) Ltd (Barytes Bricks)
Western Detail Mfrs Ltd (Lead)

SHIELDING—THERMAL
★ Circle **No 534** on reply card
Babcock & Wilcox Ltd
Beardmore & Co Ltd, William
Chatwood-Milner Ltd
Darlington Insulation Co Ltd, The
English Steel Corporation Ltd
Grey & Marten Ltd
Hadfields Ltd
International Mechanite Metal Co Ltd, The
Metal Propellers Ltd
Simon-Carves Ltd
Thompson Ltd, John

SOLVENT RECOVERY PLANT
★ Circle **No 535** on reply card
Apex Construction Ltd
British CECA Ltd
Dore Ltd
Holmes Ltd
Kestner Evaporator Ltd
Nuclear Chemical Plant Ltd
QVF Ltd
Simon-Carves Ltd
Wykeham Ltd

SOLVENTS
★ Circle **No 536** on reply card
Distillers Co Ltd
Geigy Co Ltd, The
General Chemical & Pharmaceutical Co Ltd, The
Houseman & Thompson Ltd
Howards of Ilford Ltd
Imperial Chemical Industries Ltd
Shell Chemical Co Ltd

STARTERS—MOTOR
★ Circle **No 537** on reply card
Aerospray Associated Ltd
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
C.A.V. Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The
Geipel Ltd, William
General Electric Co Ltd, The
Harland & Wolff Ltd
Metropolitan-Vickers Electrical Co Ltd
Rotax Ltd

STEEL—BARS
★ Circle **No 538** on reply card
Allen & Co Ltd, Edgar
Appleby-Frodingham Steel Co
Bairds & Scottish Steel Ltd
Beardmore & Co Ltd, William
Darwins Ltd
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
Guest Industrials Ltd
Hadfields Ltd
Hallamshire Steel Ltd
Jessop & Sons Ltd, William
Lee & Sons Ltd, Arthur
Low Moor Alloy Steelworks Ltd
Moss & Gamble Bros Ltd
Osborne & Co Ltd, Samuel
Richard Thomas & Baldwins Ltd
Rigby & Sons Ltd, John
Rubery Owen Ltd (Darlaston)
Sanderson Bros & Newbould Ltd
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
United Steel Companies Ltd, The
Wykeham Ltd

STEEL—CASTINGS
★ Circle **No 539** on reply card
Allen & Co Ltd, Edgar
APV Co Ltd, The
Armstrong Siddeley Motors Ltd
Armstrong Whitworth (Met. Ind.) Ltd
Ashwell & Nesbit Ltd
Beardmore & Co Ltd, William
Brockhouse & Co Ltd, J.
Clay Cross (Iron & Foundries) Ltd
Darwins Ltd
Distington Engineering Co Ltd
English Electric Co Ltd, The
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Follsain-Wycliffe Foundries Ltd (Heat Resisting)
Fowler & Co (Leeds) Ltd, John
Grazebrook Ltd, M. & W.
Guest Industrials Ltd
Hadfields Ltd
Head Wrightson Steel Foundries Ltd
Head Wrightson Teesdale Ltd
Hill Ltd, C. L.
Jessop & Sons Ltd, William
John Baker & Bessemer Ltd
K & L Steelfounders & Engineers Ltd
Langley Alloys Ltd
Lloyd & Co Ltd, F. H.
Millspaugh Ltd
Osborne & Co Ltd, Samuel
Peters Ltd, G. D.
Richard Thomas & Baldwins Ltd
Rubery Owen Ltd (Darlaston)
Salter Ltd, G.
Shaw Glasgow Ltd
Thompson Castings Ltd, John
United Steel Companies Ltd, The

STEEL—FORGINGS
★ Circle **No 540** on reply card
Brockhouse & Co Ltd, J.
Darwins Ltd
Beardmore & Co Ltd, William
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Eva Bros Ltd
Firth & John Brown Ltd, Thomas
Guest Industrials Ltd
Hadfields Ltd
Head Wrightson Stampings Ltd
Jessop & Sons Ltd, William
John Baker & Bessemer Ltd
Kennedy Ltd, A.
Moore & Co Ltd, W. & E.
Moss & Gamble Bros Ltd
Osborn & Co Ltd, Samuel
Richard Thomas & Baldwins Ltd
Rubery Owen Ltd (Darlaston)
Steel Peech & Tozer
United Steel Companies Ltd, The

STEEL—PLATES
★ Circle **No 541** on reply card
Appleby-Frodingham Steel Co
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Farmer & Son Ltd
Firth & John Brown Ltd, Thomas
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
Gardner & Co Ltd
General Steel & Iron Ltd
Guest Industrials Ltd
Hadfields Ltd
Low Moor Alloy Steelworks Ltd
Osborn & Co Ltd, Samuel
Richard Thomas & Baldwins Ltd
Rubery Owen Ltd (Darlaston)
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
United Steel Companies Ltd, The
Watson & Co Ltd, Robert

STEEL—SECTIONS
★ Circle **No 542** on reply card
Allen & Co Ltd, Edgar
Appleby-Frodingham Steel Co
Bairds & Scottish Steel Ltd
Brockhouse & Co Ltd, J.
Darwins Ltd
English Steel Forge & Engineering Corp Ltd
Farmer & Son Ltd
Firth & John Brown Ltd, Thomas
Gardner & Co Ltd, Henry
General Steel & Iron Ltd
Hallamshire Steel Ltd
Kennedy Ltd, A.
Low Moor Alloy Steelworks Ltd
Osborne & Co Ltd, Samuel
Rigby & Sons Ltd, John
Rubery Owen Ltd (Darlaston)
Skinningrove Iron Ltd
Southborough (Weybridge) Ltd
TI Nuclear Engineering Ltd
United Steel Companies Ltd, The
Watson & Co Ltd, Robert
Wykeham Ltd

STEEL—STAMPINGS
★ Circle **No 543** on reply card
Braby & Co Ltd, Fredr.
English Steel Corp Ltd
English Steel Forge & Engineering Corp Ltd
Firth & John Brown Ltd, Thomas
Guest Industrials Ltd
Head Wrightson Stampings Ltd
Head Wrightson Teesdale Ltd
Jessop & Sons Ltd, William
Rubery Owen Ltd (Darlaston)
Tees-Side Bridge & Engineering Ltd
Southborough (Weybridge) Ltd
United Steel Companies Ltd, The
Wilmot Breeden Ltd

STEEL—STRIP
★ Circle **No 544** on reply card
English Steel Forge & Engineering Corp Ltd
Fox & Co Ltd, Samuel
Gardner & Co Ltd, Henry
Lancashire & Corby Steel Mfg Co Ltd
Lee & Sons Ltd, Arthur
Low Moor Alloy Steelworks Ltd
Osborn & Co Ltd, Samuel
Richard Thomas & Baldwins Ltd
Rubery Owen Ltd (Darlaston)
Sanderson Bros & Newbould Ltd
Steel Co of Wales Ltd, The
Steel, Peech & Tozer
United Steel Companies Ltd, The
Wykeham Ltd

STIRRING GEAR
★ Circle **No 545** on reply card
Aiton & Co Ltd
Apex Construction Ltd
Ashworth & Parker Ltd
Balfour & Co Ltd, Henry
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Chatwood-Milner Ltd
Davey, Paxman & Co Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Globe Pneumatic Eng Co Ltd
Harris (Birmingham) Ltd, F. & R. M.
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
Kestner Evaporator Ltd
Lang London Ltd
Metal Propellers Ltd
Nuclear Engineering Ltd
QVF Ltd

STRAINERS—CHEMICAL
★ Circle **No 546** on reply card
Ashworth & Parker Ltd
Brackett & Co Ltd, F. W.
Endecotts (Filters) Ltd
Hindle & Sons Ltd, J.
Plenty & Son Ltd
Simmons & Hawker Ltd

STRAINERS—OIL
★ Circle **No 547** on reply card
Ashworth & Parker Ltd
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.
Empyrium Ltd

STRAINERS—OIL—*continued*
Endecotts (Filters) Ltd
Hindle & Sons Ltd, Joshua
Liquid Systems Ltd
Madan & Co Ltd, Charles S.
Plenty & Son Ltd
Simmons & Hawker Ltd

STRAINERS—STEAM
★ Circle **No 548** on reply card
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd, F. W.
British Steam Specialties Ltd
Empyrium Ltd
Hindle & Sons Ltd, Joshua
Madan & Co Ltd, Charles S.

STRAINERS—WATER
★ Circle **No 549** on reply card
Ashworth & Parker Ltd
Bailey & Co Ltd, Sir W. H.
Brackett & Co Ltd., F. W.
Empyrium Ltd
Endecotts (Filters) Ltd
Hindle & Sons Ltd, Joshua
Madan & Co Ltd, Charles S
Plenty & Son Ltd

SUPERHEATERS
★ Circle **No 550** on reply card
Adamson, Daniel, & Co Ltd
Babcock & Wilcox Ltd
Birwelco Ltd
Chesterfield Tube Co Ltd, The
Clarke, Chapman & Co Ltd
Empyrium Ltd
Foster Wheeler Ltd
General Electric Co Ltd, The
International Combustion Ltd
Simon-Carves Ltd
Stewarts & Lloyds Ltd
Superheater Co Ltd, The
Thompson Water Tube Boilers Ltd, John
Thompson (Wolverhampton) Ltd, John
Unit Superheater & Pipe Co Ltd
Wykeham Ltd
Yarrow & Co Ltd

SWITCHGEAR—CONTACTOR
★ Circle **No 551** on reply card
AEW Ltd
Besson & Robinson Ltd
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Donovan Electrical Co Ltd
Electric Construction Co Ltd, The
EMB Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Klockner-Moeller Ltd
Lancashire Dynamo Nevelin Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd
Midland Electrical Mfg Co Ltd
Plessey Nucleonics Ltd
Revo Electric Ltd
Reyrolle & Co Ltd, A.
Rotax Ltd
Siemens Edison Swan Ltd
Universal Control Equipment Ltd
Wykeham Ltd

SWITCHGEAR—h.t.
★ Circle **No 552** on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Brush Electrical Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Ellison Ltd, George
English Electric Co Ltd, The
Ferguson Pailin Ltd
Ferranti Ltd
General Electric Co Ltd, The
Harland & Wolff Ltd
Ionic Instruments (London) Ltd
Johnson & Phillips Ltd
Lancashire Dynamo & Crypto Ltd
Nuclear Power Plant Co Ltd, The
Reyrolle & Co Ltd, A.
Rotax Ltd
Siemens Edison Swan Ltd
Thermocontrol Installations Co Ltd
Tube Investments Ltd
Victor Products (Wallsend) Ltd

SWITCHGEAR—l.t.
★ Circle **No 553** on reply card
ASEA Electric Ltd
Austinlite Ltd
Belmos Co Ltd, The
British Thomson-Houston Co Ltd, The
Brookhirst Switchgear Ltd
Brush Electrical Ltd
Cleco Electric Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Ellison Ltd, George
English Electric Co Ltd, The
Ferguson Pailin Ltd
Ferranti Ltd
General Electric Co Ltd, The
GWB Furnaces Ltd
Ionic Instruments (London) Ltd
Johnson & Phillips Ltd
Klöckner Moeller England Ltd
Lancashire Dynamo Nevelin
Laurence, Scott & Electromotors Ltd
Nuclear Power Plant Co Ltd, The
Ottermill Switchgear Ltd
Reyrolle & Co Ltd, A.
Rotax Ltd
Salford Electrical Instruments Ltd
Siemens Edison Swan Ltd
Simplex Electric Co Ltd
Thermocontrol Installations Co Ltd
TI Nuclear Engineering Ltd
Victor Products (Wallsend) Ltd
Whipp & Bourne Ltd

TANKS
★ Circle **No 554** on reply card
Alton & Co Ltd
Allen & Sons (Tipton) Ltd, W. G. (Steel and Aluminium Alloy)
Almin Ltd
Apex Construction Ltd
Ancorite Ltd (brick, tile-lined)
APV Co Ltd, The
Ashmore, Benson, Pease & Co (Non-ferrous)
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bawn & Co Ltd, W. B.
Bennett Sons & Shears Ltd
Birmingham & Blackburn Construction Co Ltd (Mild and Stainless Steel)
Birwelco Ltd (Steel)
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr. (All Types)
Braithwaite Engineers Ltd (pressed steel)
British Industrial Engineering Co (Staffs) Ltd (All Types)
Butterfield Ltd, W. P. (Mild and Stainless Steel; Nickel and Nickel Alloy; Aluminium and Aluminium alloy)
Callow (Engineers) Ltd, F. E.
Carlson Ltd, John D.
Chatwood-Milner Ltd (Lead Lined)
Clarke, Chapman & Co Ltd
Darham Industries (London) Ltd
Davey, Paxman & Co Ltd
Dempster Ltd (m.s., c.i.)
Dore Ltd
Doulton Industrial Porcelains Ltd (Stoneware)
Downey Ltd (m.s.)
Dunlop Rubber Co Ltd
Empyrium Ltd (m.s.)
Extrudex Ltd (Plastic)
Foster Wheeler Ltd
Foster Yates & Thom Ltd (Mild Steel)
Fowler Ltd (lead)
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd (Stainless and Mild Steel)
Grazebrook Ltd, M. & W. (Mild and Stainless Steel; Aluminium)
Giusti Ltd (s.s., m.s.)
Grey & Marten Ltd (All Metals-Galvanized)
Guest Industrials Ltd
Hargreaves & Sons Ltd, Henry
Harris (Birmingham) Ltd, F. & R. M. (All Metals)
Harvey & Co (London) Ltd, G. A. (Al. Steel)
Hathernware Ltd (Stoneware)
Head Wrightson Teesdale Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K. (s.s.)
Kestner Evaporator Ltd (plastic)
Jenkins & Co Ltd, Robert
Lang London Ltd
Liquid Systems Ltd (Mild Steel)
MacLellan Ltd, G.
Marston Excelsior Ltd (Aluminium)
Mason (Chemical Engineers) Ltd, G. Samuel (All Types)
Mechans Ltd
Mendip (Chemical Engineering) Ltd (Reinforced Plastics)
Metal Propellers Ltd
Millspaugh Ltd
Mills Packard Construction Co Ltd (Steel)
Moore & Co Ltd, W. & E
Motherwell Bridge & Engineering Co Ltd
Newton, Chambers & Co Ltd (Steel)
Nuclear Engineering Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd (Stainless Steel)
Power-Gas Corporation Ltd, The
QVF Ltd (Glass)
Robertson & Ferguson Ltd (Steel)
Robey & Co Ltd (Steel)
Rubery Owen Ltd (Darlaston)
Ruston & Hornsby Ltd (Ferrous and Non-Ferrous)
Rye-Arc Ltd
Ryder & Co (Manchester) Ltd, Thos.
Sheet Metal Engineering Ltd
Simmons & Hawker Ltd (Mild Steel)
Simon-Carves Ltd
Southborough (Weybridge) Ltd (Stainless Steel)
Stainless Steel Vessels (London) Ltd
Steels Engineering Installations Ltd
Taylor Rustless Fittings Ltd (s.s.)
Tees-Side Bridge & Engineering Ltd
Thermo-Plastics Ltd
Thermal Syndicate Ltd, The (Vitreosil)
Thompson Bros (Bilston) Ltd (Al. s.s., etc.)
Thompson (Dudley) Ltd, John (Steel)
Thompson (Wolverhampton) Ltd, John (Steel)
Universal Boilers & Engineering Ltd
Vicsons Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos. W.
Widnes Foundry & Engineering Co Ltd (Steel)
Wilkinson Rubber Linatex Ltd
Windshields of Worcester Ltd
Wright, Anderson & Co Ltd (Steel)
Wykeham Ltd
Yorkshire Engineering & Welding Co Ltd

TESTING SERVICES—NON-DESTRUCTIVE
★ Circle **No 555** on reply card
Andrews & Platt (Engineers) Ltd
BTR Industries Ltd
Cawkell, Research & Electronics Ltd
CNS Instruments Ltd
Falk & Co Ltd, M.
Hawker Siddeley Nuclear Power Co Ltd.
Industrial Radiography (NDT) Ltd
Inspection Services Ltd
Madan & Co Ltd, Charles S.
Metropolitan-Vickers Electrical Co Ltd
Motherwell Bridge & Engineering Co Ltd
Newton Victor Ltd
Pantak Ltd
Towler Ltd
Unit Superheater & Pipe Co Ltd
Welding Supervision Ltd
Wykeham Ltd

TRANSFORMERS—h.t.
★ Circle **No 556** on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brush Electrical Ltd
Bryce Electrical Construction Co Ltd
Cleco Electric Ltd
Crompton Parkinson Ltd
Darlington Insulation Co Ltd, The
Electric Construction Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
Foster Transformers Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Gresham Transformers Ltd
Hackbridge & Hewittic Electric Co Ltd
Johnson & Phillips Ltd
London Transformer Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Miles Hivolt Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.

TRANSFORMERS—l.t.
★ Circle **No 557** on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Brush Electrical Ltd
Bryce Electrical Construction Co Ltd
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
Foster Transformers Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Gresham Transformers Ltd
Johnson & Phillips Ltd
London Transformer Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.
Plessey Nucleonics Ltd
Rotax Ltd
Standard Telephones & Cables Ltd

TRANSPORT FLASKS (COFFINS)
★ Circle **No 558** on reply card
Chatwood-Milner Ltd
Cravens Ltd
Dewrance & Co Ltd
Fowler Ltd (lead)
International Meehanite Metal Co Ltd, The
Jenkins & Co Ltd, Robert
QVF Ltd
Robey & Co Ltd
Westover Nuclear Equipment Ltd
Widnes Foundary & Engineering Co Ltd
Western Detail Mfrs Ltd

TRAPS—STEAM
★ Circle **No 559** on reply card
Aiton & Co Ltd
Babcock & Wilcox Ltd
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Drayton Regulator Ltd
Guest Industrials Ltd
Heat Transfer Ltd
Hopkins & Co Ltd, P.
Hopkinsons Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spirax-Sarco Ltd
Stokes, Taylor & Shaw Ltd
United States Metallic Packing Co Ltd

TUBING (*See Piping*)

TUBING—EXTENDED SURFACE
★ Circle **No 560** on reply card
Accles & Pollock Ltd (All Types)
Birkett, Billington & Newton Ltd
British Ermeto Corporation Ltd (All Types)
Clarke, Chapman & Co Ltd (Finned & Gilled in Mild Steel)
Fairey Aviation Ltd (fuel cans)
Hilmor Ltd (bending m/cs)
Hunt Heat Exchangers Ltd
Imperial Chemical Industries Ltd (All Types)
Kirk & Co (Tubes) Ltd (All Types)
Northern Aluminium Co Ltd (Aluminium—Finned)
Richards & Ross Ltd (Steel—Helical Finned)
Spanner Boilers Ltd
Spiro-Gills Ltd (Ferrous & Non-Ferrous, Helical Gilled or Plate Fins)
Stainless Steel Profile Cutters Ltd
Standard & Pochin Bros Ltd (Copper, Steel & Aluminium, Gilled)
TI Nuclear Engineering Ltd (Aluminium & Magnesium Alloys; Steel)
Tube Products Ltd
Tubes Ltd

TURBINES—GAS
★ Circle **No 561** on reply card
Adamson & Co Ltd, Daniel
Allen Sons & Co Ltd, W. H.
ASEA Electric Ltd
Bristol Aero-Engines Ltd
British Thomson-Houston Co Ltd, The
Brown Land Boilers Ltd, John
Budworth Ltd, David
Capper, Wm. H.
English Electric Co Ltd, The
Harland & Wolff Ltd
Metropolitan-Vickers Electrical Co Ltd
Parsons & Co Ltd, C. A.
Rotax Ltd
Ruston & Hornsby Ltd
Wykeham Ltd

TURBINES—STEAM
★ Circle **No 562** on reply card
Allen Sons & Co Ltd, W. H.
ASEA Electric Ltd
Belliss & Morcom Ltd
British Thomson-Houston Co Ltd, The
Brotherhood Ltd, Peter

TURBINES—STEAM—*continued*
Budworth Ltd, David
Capper Ltd, Wm. H.
English Electric Co Ltd, The
General Electric Co Ltd, The
Harland & Wolff Ltd
Hayward Tyler & Co Ltd
Nuclear Power Plant Co Ltd, The
Parsons & Co Ltd, C. A.
Richardsons Westgarth Ltd
Weir Ltd, G. & J.
Wykeham Ltd

ULTRASONIC INSPECTION EQUIPMENT
★ Circle **No 563** on reply card
Falk & Co Ltd, M.
Industrial Radiography (NDT) Ltd
Kelvin & Hughes (Industrial) Ltd
Ultrasonoscope Co (London) Ltd
Welding Supervision Ltd

VACUUM CLEANERS—INDUSTRIAL
★ Circle **No 564** on reply card
Bivac Air Co Ltd (fixed and portable)
Mancuna Engineering Ltd
New Welbeck Ltd
Service Electric Co Ltd
Sturtevant Engineering Co Ltd

VACUUM PLANT (*See Section 2*)

VALVES (by type)

Angle
★ Circle **No 565** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Fisher Governor Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Pressure Control Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Thermocontrol Installations Co Ltd
Warren, Morrison Ltd
Weir Valves Ltd

Balanced disk
★ Circle **No 566** on reply card
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough Ltd, J.
Bowing & Co Ltd
Dempster Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Hopkinsons Ltd
Milne Ltd, C. S.
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

Bellows sealed
★ Circle **No 567** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Armstrong Siddeley Motors Ltd
Babcock & Wilcox Ltd
British Ermeto Corporation Ltd
Dewrance & Co Ltd
Elliott Bros (London) Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
K.S.B. Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

Diaphragm sealed
★ Circle **No 568** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bells Asbestos Ltd
Ellison Ltd, George
Gordon & Co Ltd, James
IV Pressure Controllers Ltd
K.S.B. Ltd
Metro-Flex Atomic Engineering Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
Saunders Valve Co Ltd
Scotts Engineering Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

Globe
★ Circle **No 569** on reply card
Appleton & Howard Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Birkett, Billington & Newton Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Guest Industrials Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
K.S.B. Ltd
Langley Alloys Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Taylor Controls Ltd
Weir Valves Ltd
Wykeham Ltd

Mixing
★ Circle **No 570** on reply card
Birkett, Billington & Newton Ltd
Fisher Governor Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Kirk & Co (Tubes) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

Needle
★ Circle **No 571** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Appleton & Howard Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
Birkett, Billington & Newton Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Langley Alloys Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pressure Control Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd

Non return
★ Circle **No 572** on reply card
Alexander Controls Ltd
Appleton & Howard Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Ben Patents Ltd
Birfield Industries Ltd
Birkett, Billington & Newton Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Guest Industrials Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, J.
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
K.S.B. Ltd
Lockheed Precision Products Ltd
Madan & Co Ltd, Charles S.
Martonair Ltd
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Perfection Parts Ltd
Pressure Control Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Spembly Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd
Williams & James (Engineers) Ltd

Parallel slide
★ Circle **No 573** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Birkett, Billington & Newton Ltd
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Glenfield & Kennedy Ltd
Guest Industrials Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Holmes Ltd
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Newman, Hender & Co Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
Weir Valves Ltd

Piston
★ Circle **No 574** on reply card
Alexander Controls Ltd
Baldwin Instrument Co Ltd
Birfield Industries Ltd
Globe Pneumatic Eng Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Integral Ltd
Klinger Ltd, Richard
Leybold Vacuum Sales Ltd
Martonair Ltd
Newman, Hender & Co Ltd
Palatine Tools & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
T.A.L. Numatics Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd

Plug
★ Circle **No 575** on reply card
Appleton & Howard Ltd
Bells Asbestos Ltd
Birkett, Billington & Newton Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Elliott Bros (London) Ltd
Extrudex Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Hathernware Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
Newman, Hender & Co Ltd
Pressure Control Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
TI Nuclear Engineering Ltd
Warren Morrison Ltd

Reducing
★ Circle **No 576** on reply card
Aeraspray Associated Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Ben Patents Ltd
Bennett Sons & Shears Ltd
Birfield Industries Ltd
Birkett, Billington & Newton Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Ellison Ltd, George
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Pressure Control Ltd
Rotax Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Williams & James (Engineers) Ltd

Relief
★ Circle **No 577** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Ben Patents Ltd
Birkett, Billington & Newton Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Harland Engineering Co Ltd
High Pressure Components, Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Milne & Co Ltd, C. S.
Newman, Hender & Co Ltd
Pressure Control Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Telehoist Ltd
Towler Bros (Patents) Ltd
Williams & James (Engineers) Ltd

Safety
★ Circle **No 578** on reply card
Aeraspray Associated Ltd
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Ben Patents Ltd
Birkett, Billington & Newton Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Cockburns Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd

VALVES—by type—*continued*

Electro-Hydraulics Ltd
Guest Industrials Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Madan & Co Ltd, Charles S.
Milne Ltd, C. S.
Newman, Hender & Co Ltd
Pressure Control Ltd
Ryder & Co (Manchester) Ltd, Thomas
T.A.L. Numatics Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Williams & James (Engineers) Ltd

Sluice
★ Circle **No 579** on reply card
Appleton & Howard Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Birkett, Billington & Newton Ltd
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Howden & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
K.S.B. Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Wykeham Ltd

Wedge gate
★ Circle **No 580** on reply card
Appleton & Howard Ltd
APV Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Birkett, Billington & Newton Ltd
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Dempster Ltd
Glenfield & Kennedy Ltd
Ham, Baker & Co Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
K.S.B. Ltd
Langley Alloys Ltd
Lockheed Precision Products Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Weir Valves Ltd
Wykeham Ltd

VALVES (by operation)

Diaphragm
★ Circle **No 581** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
British Steam Specialties Ltd
Crosby Valve & Engineering Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Ellison Ltd, George
Fisher Governor Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kestner Evaporator Ltd
Martonair Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Talbot Stead Tube Co Ltd
T.A.L. Numatics Ltd
Thermocontrol Installations Co Ltd
TI Nuclear Engineering Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

Electric motor
★ Circle **No 582** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Blakeborough & Sons Ltd, J.
British Steam Specialties Ltd
Cockburns Ltd
Dewrance & Co Ltd
Ellison Ltd, George
Firkins Ltd, G. & A.
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
Hindle & Sons Ltd, Joshua
Holmes Ltd
Hopkins & Co Ltd, F.
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
N.G.N. Electrical Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Stonebridge Electrical Co Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Western Detail Mfrs Ltd
Wykeham Ltd

Hydraulic cylinder
★ Circle **No 583** on reply card
Alexander Controls Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Chamberlain Industries Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Holmes Ltd
Inness & Co (Darlington) Ltd
Integral Ltd
IV Pressure Controllers Ltd
Klinger Ltd, Richard
Lockheed Precision Products Ltd
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Short Bros & Harland Ltd
Telehoist Ltd
Towler Bros (Patents) Ltd
United States Metallic Packing Co Ltd
Warren Morrison Ltd

Pneumatic cylinder
★ Circle **No 584** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
British CECA Ltd
Crosby Valve & Engineering Co Ltd
Dewrance & Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Holmes Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Klinger Ltd, Richard
Lang Pneumatic Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Newman, Hender & Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
T.A.L. Numatics Ltd
United States Metallic Packing Co Ltd
Warren Morrison Ltd

Solenoid
★ Circle **No 585** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Babcock & Wilcox Ltd
Bells Asbestos Ltd
Birfield Industries Ltd
Cockburns Ltd
Dewrance & Co Ltd
Dowty Nucleonics Ltd
Edwards High Vacuum Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Globe Pneumatic Eng Co Ltd
Guest Industrials Ltd
Harland Engineering Co Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Jones & Stevens Ltd
Lang Pneumatic Ltd
Lock & Co Ltd, A. M.
Magnetic Equipment Co Ltd, The
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Pressure Control Ltd
Pulsometer Engineering Co Ltd, The
Rotax Ltd
Ryder & Co (Manchester) Ltd, Thomas
Scotts Engineering Ltd
T.A.L. Numatics Ltd
Teddington Industrial Equipment Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

Thermostatic
★ Circle **No 586** on reply card
General Electric Co Ltd, The
Gordon & Co Ltd, James
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd

Vacuum
★ Circle **No 587** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bell Precision Engineering Co Ltd
B.E.N. Patents Ltd
Blundell & Crompton Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Fisher Governor Ltd
Gordon & Co Ltd, James
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Leybold Vacuum Sales Ltd
Martonair Ltd
Metropolitan-Vickers Electrical Co Ltd
Newman, Hender & Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Warren Morrison Ltd
Western Detail Mfrs Ltd

VALVES (by purpose)

Air
★ Circle **No 588** on reply card
Aerospray Associated Ltd
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Ben Patents Ltd
Birfield Industries Ltd
British CECA Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Chatwood-Milner Ltd
Dewrance & Co Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Lang Pneumatic Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Metro-Flex Atomic Engineering Ltd
Milne Ltd, C. S.
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Pressure Control Ltd
Perfection Parts Ltd
Rotax Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Scotts Engineering Ltd
SPE Co Ltd (non-return)
Spembly Ltd
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

Chemicals
★ Circle **No 589** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Appleton & Howard Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
British Ermeto Corporation Ltd
Electro-Hydraulics Ltd
Extrudex Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
Hathernware Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kestner Evaporator & Engineering Co Ltd
Kirk & Co (Tubes) Ltd
K.S.B. Ltd
Langley Alloys Ltd
Millspaugh Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Plessey Nucleonics Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Scotts Engineering Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd
Western Detail Mfrs Ltd
Wykeham Ltd

Gases
★ Circle **No 590** on reply card
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Birfield Industries Ltd
Blakeborough & Sons Ltd, J.
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
Chatwood-Milner Ltd
Callow (Engineers) Ltd, F. E.
De Havilland Engine Ltd
Dempster Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Fisher Governor Ltd
Flight Refuelling Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Holmes Ltd
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
K.S.B. Ltd
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Metro-Flex Atomic Engineering Ltd
Milne Ltd, C. S.
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Plessey Nucleonics Ltd
Pressure Control Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Scotts Engineering Ltd
Walter Ltd, C. & W.

Hydraulic Control
★ Circle **No 591** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Birfield Industries Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Chamberlain Industries Ltd
Cravens Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkins & Co Ltd, F.
Hopkinsons Ltd
Integral Ltd
IV Pressure Controllers Ltd
Keelavite Hydraulics Ltd
Kirk & Co (Tubes) Ltd
Lockheed Precision Products Ltd
Madan & Co Ltd, Charles S.
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Pressure Control Ltd
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
Saunders Valve Co Ltd
Short Bros & Harland Ltd
Telehoist Ltd
Thermocontrol Installations Co Ltd
Towler Bros (Patents) Ltd
Western Detail Mfrs Ltd

Liquid Metals
★ Circle **No 592** on reply card
Appleby & Ireland Ltd
APV Co Ltd, The
Armstrong Siddeley Motors Ltd
British Ermeto Corporation Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Harland Engineering Co Ltd
Newman, Hender & Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Western Detail Mfrs Ltd

Pneumatic Control
★ Circle **No 593** on reply card
Aerospray Associated Ltd
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Ben Patents Ltd
British Ermeto Corporation Ltd
Crosby Valve & Engineering Co Ltd
Electro-Hydraulics Ltd
Ellison Ltd, George
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Globe Pneumatic Eng Co Ltd
Gordon & Co Ltd, James
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Lang Pneumatic Ltd
Leybold Vacuum Sales Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Newman, Hender & Co Ltd
Norgren Ltd, C. A.
Perfection Parts Ltd
Pressure Control Ltd
Rotax Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Scotts Engineering Ltd
T.A.L. Numatics Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
United States Metallic Packing Co Ltd

Steam
★ Circle **No 594** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Bailey & Co Ltd, Sir W. H.
Bells Asbestos Ltd
Birfield Industries Ltd
Birkett, Billington & Newton Ltd
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Crosby Valve & Engineering Co Ltd
Cockburns Ltd
Dewrance & Co Ltd
Fisher Governor Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Hopkinsons Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
K.S.B. Ltd
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Shaw-Petrie Ltd
Stewarts & Lloyds Ltd
Thermocontrol Installations Co Ltd
United States Metallic Packing Co Ltd
Weir Valves Ltd
Wykeham Ltd

Vacuum ★ Circle **No 595** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Baldwin Instrument Co Ltd
Ben Patents Ltd
Blundell & Crompton Ltd
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Edwards High Vacuum Ltd
Fisher Governor Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Hindle & Sons Ltd, Joshua
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
K.S.B. Ltd
Leybold Vacuum Sales Ltd
Magnetic Valve Co Ltd, The
Martonair Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne Ltd, C. S.
Newman, Hender & Co Ltd
NGN Electrical Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Perfection Parts Ltd
Pulsometer Engineering Co Ltd, The
Ryder & Co (Manchester) Ltd, Thomas
Sandall Precision Ltd
Saunders Valve Co Ltd
Scotts Engineering Ltd
Stainless Steel Vessels (London) Ltd
Sykes Ltd, Henry
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

Water ★ Circle **No 596** on reply card
Alexander Controls Ltd
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Baldwin Instrument Co Ltd
Bells Asbestos Ltd
Birfield Industries Ltd
Birkett, Billington & Newton Ltd
Blakeborough & Sons Ltd, J.
British Ermeto Corporation Ltd
British Steam Specialties Ltd
Cockburns Ltd
Dewrance Ltd
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Elliott Bros (London) Ltd
Extrudex Ltd
Fisher Governor Ltd
Glenfield & Kennedy Ltd
Gordon & Co Ltd, James
Ham, Baker & Co Ltd
Harland Engineering Co Ltd
High Pressure Components Ltd
Hindle & Sons Ltd, Joshua
Horseley Bridge & Thomas Piggott Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
Jones & Stevens Ltd
Kirk & Co (Tubes) Ltd
Klinger Ltd, Richard
K.S.B. Ltd
Langley Alloys Ltd
Magnetic Valve Co Ltd, The
Millspaugh Ltd
Newman, Hender & Co Ltd
Perfection Parts Ltd
Ryder & Co (Manchester) Ltd, Thomas
Saunders Valve Co Ltd
Scotts Engineering Ltd
Trinity Pumps Ltd
United States Metallic Packing Co Ltd
Weir Valves Ltd
Wykeham Ltd

VENTILATORS—NATURAL DRAUGHT
★ Circle **No 597** on reply card
Andrew Machine Construction Co Ltd, The
Birmingham & Blackburn Construction Co Ltd
Colt Ventilation Ltd
Fenton, Byrn & Co Ltd
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Hills (West Bromwich) Ltd
Mancuna Engineering Ltd
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Supervents Ltd
Tupholme & Co Ltd, George E.
Walker & Co (Halifax) Ltd, P. M.

VENTILATORS—MECHANICAL EXTRACT
★ Circle **No 598** on reply card
Aerospray Associated Ltd
Andrew Machine Construction Co Ltd, The
Biddle Ltd, F. H.
Birmingham & Blackburn Construction Co Ltd
Capper Ltd, Wm. H.
Carrier Engineering Co Ltd
Colt Ventilation Ltd
Davidson & Co Ltd
Extrudex Ltd
Fenton, Byrn & Co Ltd
General Electric Co Ltd, The
Hargreaves & Sons Ltd, Henry
Harvey & Co (London) Ltd, G. A.
Hills (West Bromwich) Ltd
Keith Blackman Ltd
Mancuna Engineering Ltd
Ozonair Engineering Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Standard & Pochin Bros Ltd, The
Sturtevant Engineering Co Ltd
Supervents Ltd
Tupholme & Co Ltd, George E.
Vent-Axia Ltd
Walker & Co (Halifax) Ltd, P. M.
Woods of Colchester Ltd
Wykeham & Co Ltd, W.

VESSELS—CHEMICAL REACTION
★ Circle **No 599** on reply card
Adamson & Co Ltd, Daniel
Apex Construction Ltd
APV Co Ltd, The
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Chesterfield Tube Co Ltd, The
Constructors John Brown Ltd
Davey, Paxman & Co Ltd
Dempster Ltd
Dore Ltd
English Steel Corporation Ltd
Empyrium Ltd
Extrudex Ltd
Foster, Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Hathernware Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Heat Transfer Ltd
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, G. Samuel
Metal Propellers Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
QVF Ltd
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Simon-Carves Ltd
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Taylor Rustless Fittings Ltd
Thompson Bros (Bilston) Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Towler Ltd
Universal Boilers & Engineering Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd
Widnes Foundry & Engineering Co Ltd
Wykeham Ltd

VESSELS—LEAD LINED
★ Circle **No 600** on reply card
Birmingham & Blackburn Contruction Co Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Dore Ltd
Fowler Ltd
Giusti Ltd
Grazebrook Ltd, M. & W.
Guest Industrials Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Jenkins & Co Ltd, Robert
Kestner Evaporator & Engineering Co Ltd
Mason (Chemical Engineers) Ltd, Samuel G.
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Towler Ltd
Universal Boilers & Engineering Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

VESSELS—PRESSURE
★ Circle **No 601** on reply card
Aerospray Associated Ltd
Aerox Ltd
Alton & Co Ltd
Allen & Sons (Tipton) Ltd, W. G.
APV Co Ltd, The
Ashmore, Benson, Pease & Co
Ayling Nuclear Equipment Co
Babcock & Wilcox Ltd
Balfour & Co Ltd, Henry
Bawn & Co Ltd, W. B.
Beardmore & Co Ltd, William
Bennett Sons & Shears Ltd
Birkett, Billington & Newton Ltd
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Blundell & Crompton Ltd
Braby & Co Ltd, Fredr.
Bristol Aircraft Ltd
Brown Land Boilers Ltd, John
Burnett & Lewis Ltd
Butterfield Ltd, W. P.
Capper & Co Ltd, William H.
Chatwood-Milner Ltd
Chesterfield Tube Co Ltd, The
Clarke, Chapman & Co Ltd
Cochran, Annan Ltd
Cravens Ltd
Darham Industries (London) Ltd
Davey, Paxman & Co Ltd
Dempster Ltd
Dore Ltd
Electro-Hydraulics Ltd
Empyrium Ltd
English Steel Corp Ltd
Foster Wheeler Ltd
Foster Yates & Thom Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
General Electric Co Ltd, The
Giusti Ltd
Grazebrook Ltd, M. & W.
Guest Industries Ltd
Hargreaves & Sons Ltd, Henry
Harris (Birmingham) Ltd, F. & R. M.
Harvey & Co (London) Ltd, G. A.
Head Wrightson & Co Ltd (Nuclear Power Div)
Head Wrightson Processes Ltd
Heat Exchangers Ltd
Heat Transfer Ltd
Hobson Ltd, H. M.
Horseley Bridge & Thomas Piggott Ltd
Innes Ltd, J. K.
International Combustion Ltd
IV Pressure Controllers Ltd
Jenkins & Co Ltd, Robert
Marshall & Co (Motherwell) Ltd, John
Marston Excelsior Ltd (Aluminium Only)
Mechanair
Millspaugh Ltd

VESSELS—PRESSURE—*continued*
Moore & Co Ltd, W. & E.
Morrison, Marshall & Hill Ltd
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers & Co Ltd
Nuclear Power Plant Co Ltd, The
Pearson & Sons Ltd, T. B.
Press & Son Ltd, W.
Robertson & Ferguson Ltd
Robey & Co Ltd
Rubery Owen Ltd (Warrington)
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Rye-Arc Ltd
Sheet Metal Engineering Ltd
Simmons & Hawker Ltd
Simon-Carves Ltd
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Steels Engineering Installations Ltd
Taylor Rustless Fittings Ltd
Tees-Side Bridge & Engineering Ltd
Thompson Bros (Bilston) Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Towler Ltd
Unit Superheater & Pipe Co Ltd, The
Universal Boilers & Engineering Ltd
Vickers-Armstrongs (A/C) Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos W.
Watson & Co Ltd, Robert
Western Detail Mfrs Ltd
Whessoe Ltd
Widnes Foundry & Engineering Co Ltd
Williams & James (Engineers) Ltd
Wilmot Breeden Ltd
Windshields of Worcester Ltd
Wykeham Ltd
Yarrow & Co Ltd

VESSELS—STAINLESS STEEL
★ Circle **No 602** on reply card
Apex Construction Ltd
APV Co Ltd, The
Birmingham & Blackburn Construction Co Ltd
Birwelco Ltd
Butterfield Ltd, W. P.
Cravens Ltd
Cockran, Annan Ltd
Davey Paxman Ltd
Dempster Ltd
Dore Ltd
Electro-Hydraulics Ltd
Fraser & Co Ltd, W. J.
Freeman, Taylor Machines Ltd
Giusti Ltd
Grazebrook Ltd, M. & W.
Guest Industrials Ltd
Head Wrightson & Co Ltd (Nuclear Power Div)
Heat Exchangers Ltd
Heat Transfer Ltd
Jenkins & Co Ltd, Robert
Mason (Chemical Engineers) Ltd, G. Samuel
Metaducts Ltd
Moore & Co Ltd, W. & E.
Motherwell Bridge & Engineering Co Ltd, The
Munro & Miller Ltd
Newton, Chambers Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Press & Son Ltd, W.
Ruston & Hornsby Ltd
Ryder & Co (Manchester) Ltd, Thomas
Southborough (Weybridge) Ltd
Stainless Steel Vessels (London) Ltd
Taylor Rustless Fittings Ltd
Thompson Bros (Bilston) Ltd
Thompson (Dudley) Ltd, John
Thompson (Wolverhampton) Ltd, John
Towler Ltd
Universal Boilers & Engineering Ltd
Walker Ltd, C. & W.
Ward Ltd, Thos W.
Watson & Co Ltd, Robert
Western Detail Mfrs Ltd
Wilmot Breeden Ltd
Wykeham Ltd

WELDING BLOWPIPES
★ Circle **No 603** on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Centrajet Ltd
Invicta Electrodes Ltd
Milne & Co Ltd, C. S.
Oxhycarbon Co Ltd
Peters Ltd, G. D.
Pollock & Peel Ltd
Rubery Owen Ltd
Saturn Industrial Gases Ltd

WELDING ELECTRODES
★ Circle **No 604** on reply card
Arc Mfg Co Ltd
Armco Ltd
British Insulated Callender's Cables Ltd
Cooper & Turner
Deloro Stellite Ltd
English Electric Co Ltd, The
Eutectic Welding Alloys Ltd
Fuller Electric Co Ltd
Invicta Electrodes Ltd
Lincoln Electric Co Ltd
Max Arc & Electrics Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Quasi-Arc Ltd
Philips Electrical Ltd
Rediweld-Oerlikon Electrodes Ltd
Rowenarc Ltd
Rockweld Ltd
Sciaky Electric Welding Machines Ltd
Siebe, Gorman & Co Ltd
Welding Supplies Ltd

WELDING ELECTRODE HOLDERS
★ Circle **No 605** on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
Balbo Welding Processes Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Invicta Electrodes Ltd
Lincoln Electric Co Ltd
Max Arc & Electrics Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Quasi-Arc Ltd
Peters Ltd, G. D.
Philips Electrical Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Ross & Partners Ltd, Donald
Rowenarc Ltd
Rubery Owen Ltd
Siebe, Gorman & Co Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING FLUXES
★ Circle **No 606** on reply card
Armco Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Eutectic Welding Alloys Ltd
Fuller Electric Ltd
Lincoln Electric Co Ltd
Milne & Co Ltd, C. S.
Philips Electrical Ltd
Sheffield Smelting Co Ltd, The
Suffolk Iron Foundry (1920) Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING GASES
★ Circle **No 607** on reply card
British Industrial Gases Ltd
British Oxygen Gases Ltd (Oxygen, Acetylene, Nitrogen, Argon, Propane, Hydrogen, Coal Gas Compressed Air)
Imperial Chemical Industries Ltd (Argon)
Saturn Industrial Gases Ltd (Propane, Argon)

WELDING GAS REGULATORS
★ Circle **No 608** on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Invicta Electrodes Ltd
Milne & Co Ltd, C. S.
Oxhycarbon Co Ltd
Saturn Industrial Gases Ltd
Siebe, Gorman & Co Ltd
Suffolk Iron Foundry (1920) Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—PROJECTION
★ Circle **No 609** on reply card
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd

WELDING MACHINES—SEAM
★ Circle **No 610** on reply card
Bode & Son Ltd, F.
British Federal Welder & Mc. Co Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Igranic Electric Co Ltd
Invicta Electrodes Ltd
Lancashire Dynamo Electronic Products Ltd
Meritus (Barnet) Ltd
Metro-Cutanit Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Philips Electrical Ltd
Sciaky Electric Welding Machines Ltd
Soag Machine Tools Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—SHIELDED ARC
★ Circle **No 611** on reply card
Arc Mfg Co Ltd
British Oxygen Gases Ltd
Lincoln Electric Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rockweld Ltd
Saturn Industrial Gases Ltd

WELDING MACHINES—SPOT
★ Circle **No 612** on reply card
Baddeley Engineering Co Ltd, D. S.
British Federal Welder & Mc. Co Ltd
British Oxygen Gases Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Hirst Electronic Ltd
Igranic Electric Co Ltd
Invicta Electrodes Ltd
Lancashire Dynamo Electronic Products Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Philips Electrical Ltd
Rowenarc Ltd
Rubery Owen Ltd
Soag Machine Tools Ltd
Sciaky Electric Welding Machines Ltd
Young & Co Ltd, A. S.

WELDING MACHINES—STUD
★ Circle **No 613** on reply card
Crompton Parkinson Ltd
Electro Mechan-Heat Ltd
Fuller Electric Ltd
Meritus (Barnet) Ltd
Philips Electrical Ltd
Sciaky Electric Welding Machines Ltd

WELDING MACHINES—SUBMERGED ARC
★ Circle **No 614** on reply card
Lincoln Electric Co Ltd
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Rockweld Ltd
Welding Supplies Ltd

WELDING MOTOR GENERATOR SETS
★ Circle **No 615** on reply card
Armco Ltd
Fuller Electric Co Ltd
General Electric Co Ltd, The
Invicta Electrodes Ltd
Lincoln Electric Co Ltd
Max Arc & Electrics Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Philips Electrical Ltd
Petbow Ltd
Peters Ltd, G. D.
Purchas Ltd
Quasi-Arc Ltd
Rediweld-Oerlikon Electrodes Ltd
Rowenarc Ltd
Rubery Owen Ltd
Universal Boilers & Engineering Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WELDING POSITIONERS
★ Circle **No 616** on reply card
Bode & Son Ltd, F.
Courtourn Positioners Ltd
Lincoln Electric Ltd
Metropolitan-Vickers Electrical Co Ltd
Neill & Co (Sheffield) Ltd, James
Quasi-Arc Ltd
Ross & Partners Ltd, Donald
Yates Plant Ltd

WELDING PREHEATING EQUIPMENT
★ Circle **No 617** on reply card
Acetylene Generator & Tool Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Industrial Gases Ltd
British Oxygen Gases Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Oxhycarbon Co Ltd
Quasi-Arc Ltd
Saturn Industrial Gases Ltd

WELDING RECTIFIERS
★ Circle **No 618** on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
British Oxygen Gases Ltd
Cleco Electric Ltd
Crompton Parkinson Ltd
English Electric Co Ltd, The
Foster Transformers Ltd
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Lincoln Electric Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Murex Welding Processes Ltd
Philips Electrical Ltd
Quasi-Arc Ltd

WELDING TRANSFORMERS
★ Circle **No 619** on reply card
Arc Mfg Co Ltd
Baddeley Engineering Co Ltd, D. S.
Balbo Welding Processes Ltd
British Oxygen Gases Ltd
Cleco Electric Ltd
Electro Mechan-Heat Ltd
English Electric Co Ltd, The
Foster Transformers Ltd
Fuller Electric Ltd
General Electric Co Ltd, The
Hirst Electronic Ltd
Hackbridge & Hewittic Electric Co Ltd
Lincoln Electric Ltd
Meritus (Barnet) Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne & Co Ltd, C. S.
Murex Welding Processes Ltd
Philips Electrical Ltd
Quasi-Arc Ltd
Rockweld Ltd
Welding Industries Ltd
Welding Supplies Ltd
Young & Co Ltd, A. S.

WIREWORK—PROTECTIVE
★ Circle **No 620** on reply card
Barns & Son Ltd, W.
Braby & Co Ltd, Fredr
Endecotts (Filters) Ltd
Farmer & Son Ltd
Harvey Ltd, G. A.

Section 2

Instruments and laboratory equipment

ABSORBERS—RADIATION
★ Circle **No 621** on reply card
General Electric Co Ltd, The (heavy alloy)
Isotope Developments Ltd
Labgear Ltd
Mendip (Chemical Engineering) Ltd
Panax Equipment Ltd
Research & Control Instruments Ltd

ABSORPTIOMETERS
★ Circle **No 622** on reply card
Baird & Tatlock (London) Ltd
Evans Electroselenium Ltd
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Joyce, Loebl & Co Ltd
Lock & Co Ltd, A. M.

ACCELERATORS—PARTICLE
★ Circle **No 623** on reply card
High Voltage Servicing Ltd (Van de Graaff, linear)
Metropolitan-Vickers Electrical Co Ltd
Miles Hivolt Ltd
Mullard Equipment Ltd (travelling ware, electron linear)
Research & Control Instruments Ltd

ACCUMULATORS—*See Batteries*

AIR SAMPLING EQUIPMENT
★ Circle **No 624** on reply card
Barcross Ltd
Casella & Co Ltd, C. F.
Fleming Radio (Developments) Ltd
Minerva Detector Co Ltd
Nash & Thompson Ltd
Rotheroe & Mitchell Ltd
Winston Electronics Ltd

ALARMS—FLOW
★ Circle **No 625** on reply card
Accurate Recording Instrument Co, The
Allied Electronics Ltd
Dowty Nucleonics Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
KDG Instruments Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Liquid Systems Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Negretti & Zambra Ltd
Rotameter Mfg Co Ltd
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

ALARMS—HIGH FLUX
★ Circle **No 626** on reply card
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd

ALARMS—PRESSURE
★ Circle **No 627** on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Dowty Nucleonics Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Hopkinsons Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
KGD Instruments Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

ALARMS—RADIATION
★ Circle **No 628** on reply card
British Thomson-Houston Co Ltd, The
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
General Electric Co Ltd, The
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

ALARMS—TEMPERATURE
★ Circle **No 629** on reply card
Accurate Recording Instrument Co, The
Allied Electronics Ltd
Appleby & Ireland Ltd
British Thomson-Houston Co Ltd, The
Cambridge Instrument Co Ltd
Electro Methods Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Kent Ltd, George
KDG Instruments Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Negretti & Zambra Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
Universal Control Equipment Ltd

AMPLIFIERS—d.c.
★ Circle **No 630** on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Avo Ltd
Bailey Meters & Controls Ltd
B & K Laboratories Ltd
Boulton Paul Aircraft Ltd
British Physical Laboratories
British Thomson-Houston Co Ltd, The
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Electroflo Ltd
Electro Methods Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Falk & Co Ltd, M.
Fielden Electronics Ltd
Foster Instruments Ltd
General Radiological Ltd
Holiday & Hemmerdinger Ltd
Hilger & Watts Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Labgear (Cambridge) Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Microwave Instruments Ltd
Murphy Radio Ltd
Nagard Ltd
Nash & Thompson Ltd
Newmark Ltd
Panax Ltd
Plessey Nucleonics Ltd
Pye Ltd
Racal Engineering Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Richmond Instrument Co Ltd
Rubery Owen Ltd (Darlaston)
Savage & Parsons Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Sealey Engineering Co Ltd
Short Bros & Harland Ltd
Solartron Electronic Group Ltd
Southern Instruments Ltd
Sullivan Ltd, H. W.
Sunvic Controls Ltd
Tinsley & Co Ltd, H.
Venner Electronics Ltd

AMPLIFIERS—MAGNETIC
★ Circle **No 631** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Thomson-Houston Co Ltd, The
Electro Methods Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Hirst Electronic Ltd
Ketay Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Livingston Laboratories Ltd
Metropolitan-Vickers Electrical Co Ltd
Newmark Ltd
Pullin & Co Ltd, R. B.
Pye Ltd
Racal Engineering Ltd
Rotax Ltd
Sealey Engineering Co Ltd
Winston Electronics Ltd

AMPLIFIERS—PULSE
★ Circle **No 632** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Physical Laboratories
Cawkell Research & Electronics Ltd
Dynatron Radio Ltd
Elliott Nucleonics Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Nagard Ltd
Newmark Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

AMPLIFIERS—WIDE-BAND
★ Circle **No 633** on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Boulton Paul Aircraft Ltd
British Physical Laboratories
Cawkell Research & Electronics Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Glass Developments Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Standard Telephones & Cables Ltd

ANALYSERS—COINCIDENCE & ANTI-COINCIDENCE
★ Circle **No 634** on reply card
Dynatron Radio Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Sunvic Controls Ltd

ANALYSERS—FREQUENCY
★ Circle **No 635** on reply card
Airmec Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
Dawe Instruments Ltd
General Electric Co Ltd, The
Integra, Leeds & Northrup Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Mervyn Instruments Ltd
Muirhead & Co Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Standard Telephones & Cables Ltd
Wayne Kerr Laboratories Ltd

ANALYSERS—FUNCTION
★ Circle **No 636** on reply card
Livingston Laboratories Ltd
Mervyn Instruments
Solartron Electronic Group Ltd
Southern Instruments (Computer Division)

ANALYSERS—GAS
★ Circle **No 637** on reply card
Baird & Tatlock (London) Ltd
Baker Platinum Div, Engelhard Industries Ltd
Cambridge Instrument Co Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Glass Developments Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Infra-Red Development Co Ltd, The
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Mervyn Instruments
Metropolitan-Vickers Electrical Co Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.
Wykeham Ltd

ANALYSERS—HEAVY WATER
★ Circle **No 638** on reply card
Mervyn Instruments

ANALYSERS—PARTICLE SIZE
★ Circle **No 639** on reply card
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Mullard Equipment Ltd
Research & Control Instruments Ltd
Sharples Centrifuges Ltd

ANALYSERS—PULSE AMPLITUDE (SINGLE CHANNEL)
★ Circle **No 640** on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
Elliott Nucleonics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nuclear Enterprises (GB) Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

ANALYSERS—PULSE AMPLITUDE (MULTI CHANNEL)
★ Circle **No 641** on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Marshall's of Cambridge Electronics Ltd
Mullard Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Solartron Electronic Group Ltd
Southern Instruments, Computer Division
Sunvic Controls Ltd

ANALYSERS—TIME (TIME SORTERS)
★ Circle **No 642** on reply card
Cawkell Research & Electronics Ltd
Falk & Co Ltd, M.
Leland Instruments Ltd
Rank Cintel Ltd

ANALYSERS—URANIUM
★ Circle **No 643** on reply card
Mervyn Instruments

ANNUNCIATORS
★ Circle **No 644** on reply card
Chamberlain & Hookham Ltd
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Wykeham Ltd

ANTI-VIBRATION MOUNTINGS
★ Circle **No 645** on reply card
B. & K. Laboratories Ltd
BTR Industries Ltd
Clayton-Wright Ltd
Elliott Bros Ltd
Elliott Nucleonics Ltd
Fenner & Co Ltd, J. H.
Metalastik Ltd
Precision Rubbers Ltd
Silentbloc Ltd
Stewart Aeronautical Ltd
Trist & Co Ltd, Ronald
Walker & Co Ltd, James
Whitby & Chandler Ltd

ASSAY INSTRUMENTS
★ Circle **No 646** on reply card
Allied Electronics Ltd
Casella & Co Ltd, C. F.
Falk & Co Ltd, M.
Ekco Electronics Ltd
Ericsson Telephones Ltd
Isotope Developments Ltd
Labgear Ltd
Mervyn Instruments
Panax Equipment Ltd
Research & Control Instruments Ltd
Southern Instruments (Computer Division)

AUTOCLAVES—LABORATORY
★ Circle **No 647** on reply card
Apex Construction Ltd
Baird & Tatlock (London) Ltd
Blundell & Crompton Ltd
Chatwood-Milner Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Guest Industrials Ltd
Hadfields Ltd
Hospital & Laboratory Supplies Ltd
Morrison, Marshall & Hill Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Stabilag Co Ltd, The
Stainless Steel Vessels (London) Ltd
Taylor Rustless Fittings Ltd
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd

BADGES—FILM
★ Circle **No 648** on reply card
Electronic Machine Co Ltd (holders and service)
Ilford Ltd (film)
Kodak Ltd (film)
Savage & Parsons Ltd (holders)

BALANCES—PRECISION
★ Circle **No 649** on reply card
Baird & Tatlock (London) Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hilger & Watts Ltd
Shandon Scientific Co Ltd
Sharples Centrifuges Ltd
Stanton Instruments Ltd
Towers & Co Ltd, J. W.
Webb Ltd, William A.
Wykeham Ltd

BALANCES—RECORDING
★ Circle **No 650** on reply card
Sharples Centrifuges Ltd
Stanton Instruments Ltd
Webb Ltd, William A.

BATTERIES
★ Circle **No 651** on reply card
Alto Instruments (GB) Ltd
C.A.V. Ltd
Chloride Batteries Ltd
Crompton Parkinson Ltd
D.P. Battery Co Ltd, The
Siemens Edison Swan Ltd
Stewart Aeronautical Ltd
Venner Ltd

BELLOWS—METAL
★ Circle **No 652** on reply card
Appleby & Ireland Ltd
Dore Ltd
Engineering Appliances Ltd
Filton Ltd
Leybold Vacuum Sales Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Power Flexible Tubing Co Ltd, The
Precision Heating Ltd
Teddington Aircraft Controls Ltd
Teddington Industrial Equipment Ltd
TI Nuclear Engineering Ltd

CABINETS—PRESSURIZED ASSEMBLY
★ Circle **No 653** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
BMB (Sales) Ltd
Falk & Co Ltd, M.
Hutcheon Duthie & Co Ltd, R.
Lund Bros Ltd
Marine & Industrial Plastics Ltd
QVF Ltd
Ryder & Co (Manchester) Ltd, Thomas
South London Electrical Equipment Co Ltd
Southborough (Weybridge) Ltd
Western Detail Mfrs Ltd

CAMERAS—CATHODE RAY OSCILLOGRAPH
★ Circle **No 654** on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Avimo Ltd
Cossor Instruments Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nagard Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Savage & Parsons Ltd
Short Bros & Harland Ltd
Southern Instruments
Wykeham Ltd

CAMERAS—CINE
★ Circle **No 655** on reply card
Kodak Ltd
Leland Instruments Ltd
Vinten Ltd
Weyers Bros Ltd

CAMERAS—HIGH SPEED
★ Circle **No 656** on reply card
Avimo Ltd
General Radiological Ltd
Kodak Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Nash & Thompson Ltd
Savage & Parsons Ltd
Vinten Ltd
Weyers Bros Ltd
Winston Electronics Ltd

CAMERAS—INDUSTRIAL
★ Circle **No 657** on reply card
Avimo Ltd
Livingston Laboratories Ltd
Mason & Sons Ltd, E. N.
Ross Ensign Ltd
Savage & Parsons Ltd

CAMERAS—SPECTROSCOPIC
★ Circle **No 658** on reply card
Hilger & Watts Ltd
Leland Instruments Ltd
Pye Ltd

CAMERAS—X-RAY DIFFRACTION
★ Circle **No 659** on reply card
General Radiological Ltd
Hilger & Watts Ltd
Pye, Ltd
Research & Control Instruments Ltd
Solus-Schall Ltd

CAPACITORS—HIGH VOLTAGE
★ Circle **No 660** on reply card
Dubilier Condenser Co (1925) Ltd
Holiday & Hemmerdinger Ltd
Laboratory Apparatus & Glass Blowing Co
Leland Instruments Ltd
Livingston Laboratories Ltd
Miles Hivolt Ltd
Plessey Nucleonics Ltd
Standard Telephones & Cables Ltd
Telegraph Condenser Co Ltd, The
Tinsley & Co Ltd, H.

CASES—INSTRUMENT
★ Circle **No 661** on reply card
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G. (flame and explosion arresting)
Avimo Ltd
Brown & Co Ltd, E. G.
Dynatron Radio Ltd
Ericsson Telephones Ltd
Imhofs Ltd
Ionic Instruments (London) Ltd
Kimberley Engineering Ltd
Labgear Ltd
Leland Instruments Ltd
Lund Bros Ltd
McKellen Automation Ltd
Microwave Instruments Ltd
Motor Panels Ltd
Panax Equipment Ltd
Permali Ltd
Rank Cintel Ltd
Rubery Owen Ltd (Darlaston)
Southborough (Weybridge) Ltd
Winston Electronics Ltd

CENTRIFUGES—LABORATORY
★ Circle **No 662** on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Bryans Aeroquipment Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Laboratory Apparatus & Glass Blowing Co.
Lang London Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Sharples Centrifuges Ltd
Vicsons Ltd
Western Detail Mfrs Ltd

CHEMICALS—LABORATORY
★ Circle **No 663** on reply card
General Chemical & Pharmaceutical Co Ltd, The
Griffin & George Ltd
Guest Industrials Ltd
Hopkins & Williams Ltd
Midland Silicones Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.

CHROMATOGRAPHY APPARATUS
★ Circle **No 664** on reply card
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hanovia Lamps
Isotope Developments Ltd
Joyce, Loebl & Co Ltd
Labgear Ltd
Laboratory Apparatus & Glass Blowing Co
Lock & Co Ltd, A. M.
Metropolitan-Vickers Electrical Co Ltd
Quickfit & Quartz Ltd
QVF Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Towers & Co Ltd, J. W

COMPUTERS—ANALOGUE
★ Circle **No 665** on reply card
Air Trainers Link Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Eversbed & Vignoles Ltd
Fairey Aviation Co Ltd, The
Ferranti Ltd
Hawker Siddeley Nuclear Power Ltd
I.C.T. Ltd
Joyce, Loebl Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Miles Hivolt Ltd
Mullard Ltd
Nash & Thompson Ltd
Newmark Ltd
Pye Ltd
Saunders-Roe Ltd
Short Bros & Harland Ltd
Solartron Electronic Group Ltd
Southern Instruments (Computer Division)
Sunvic Controls Ltd
Weyers Bros Ltd

COMPUTERS—DIGITAL
★ Circle **No 666** on reply card
Blackburn Electronics Ltd (data loggers)
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferranti Ltd
IBM (UK) Ltd
I.C.T. Ltd
Leland Instruments Ltd
Metropolitan-Vickers Electrical Co Ltd
Pye Ltd
Southern Instruments (Computer Division)
Standard Telephones & Cables Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Weyers Bros Ltd

COMPUTING SERVICES
★ Circle **No 667** on reply card
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ferranti Ltd
Hawker Siddeley Nuclear Power Co Ltd
IBM (UK) Ltd
I.C.T. Ltd
Short Bros & Harland Ltd
Vickers-Armstrongs (A/C) Ltd

CONNECTORS—WIRE & CABLE
★ Circle **No 668** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Besson & Robinson Ltd (co-axial)
CWC Equipment Ltd
Electro Methods Ltd
Plessey Nucleonics Ltd
Transradio Ltd

CONTAINERS—ISOTOPE
★ Circle **No 669** on reply card
Andrews, Cuthbert
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd
British Lead Mills Ltd
Chatwood-Milner Ltd
Ekco Electronics Ltd
Enthoven Ltd
BRD Engineering Co Ltd
Falk & Co Ltd, M.
Fowler Ltd
Gammax Ltd
General Electric Co Ltd, The
General Radiological Ltd
Grey & Marten Ltd
Hull & Sons Ltd, F.
Inspection Services Ltd
Isotope Developments Ltd
Johnson, Matthey & Co Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Ltd
Newton Victor Ltd
Nuclear Engineering Ltd
Panax Equipment Ltd
Pantak Ltd
Randall Ltd, P. E.
Rediweld Ltd
Research & Control Instruments Ltd
Roberts Ltd, R. E.
Savage & Parsons Ltd
Solus-Schall Ltd
Western Detail Mfrs Ltd
Westover Nuclear Equipment Co Ltd

CONTAINERS—LINED
★ Circle **No 670** on reply card
Butterfield Ltd, W. P.
Dale Ltd, John
Mills Packard Construction Co Ltd
Rediweld Ltd

CONTROLLERS—FLOW
★ Circle **No 671** on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Birfield Industries Ltd
Crosby Valve & Engineering Co Ltd
Elcontrol Ltd
Elliott Bros. (London) Ltd
Eversbed & Vignoles Ltd
Firth Cleveland Instruments Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell Controls Ltd
Hopkins & Co Ltd, F.
Hutcheon Duthie & Co Ltd, R.
Ionic Instruments (London) Ltd
IV Pressure Controllers Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Milne Ltd, C. S.
Parkinson & Cowan Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Rotameter Mfg Co Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Ultrasonics Ltd
Wykeham Ltd

CONTROLLERS—FURNACE
★ Circle **No 672** on reply card
Appleby & Ireland Ltd
Cambridge Instrument Co Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd
Gordon & Co Ltd, James
Hirst Electronic Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Metropolitan-Vickers Electrical Co Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Western Detail Mfrs Ltd
West Instruments Ltd
Wykeham Ltd

CONTROLLERS—LEVEL
★ Circle **No 673** on reply card
Airmec Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Crosby Valve & Engineering Co Ltd
Ekco Electronics Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Firth Cleveland Instruments Ltd
Gordon & Co Ltd, James
Hopkin & Co Ltd, F.
Ionic Instruments (London) Ltd
Isotope Developments Ltd
KDG Instruments Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Meynell & Sons Ltd
Negretti & Zambra Ltd
Parkinson & Cowan Ltd
Reavell & Co Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Trist & Co Ltd, Ronald
Ultrasonics Ltd
Weir Ltd, G. & S.
Wykeham Ltd

CONTROLLERS—pH
★ Circle **No 674** on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Griffin & George Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Reavell & Co
Research & Control Instruments Ltd
Wykeham Ltd

CONTROLLERS—PRESSURE
★ Circle **No 675** on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Bailey & Co Ltd, Sir W. H.
Cambridge Instrument Co Ltd
Crosby Valve & Engineering Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell Controls Ltd
Hopkin & Co Ltd, F.
Hopkinsons Ltd
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
Isenthal & Co Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Ltd
McKellen Automation Ltd
Milne Ltd, C. S.
Negretti & Zambra Ltd
Parkinson & Cowan Ltd
Pressure Control Ltd
Reavell & Co Ltd
Salford Electrical Instruments Ltd
Savage & Parsons Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Williams & James Ltd
Wykeham Ltd

CONTROLLERS—PROGRAMME
★ Circle **No 676** on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Cawkell Research & Electronics Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
McKellen Automation Ltd
Negretti & Zambra Ltd
Reavell & Co
Research & Control Instruments Ltd
Scaley Engineering Co Ltd
Southern Instruments (Computer Division)
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
Wykeham Ltd

CONTROLLERS—TEMPERATURE
★ Circle **No 677** on reply card
Accurate Recording Instrument Co, The
Airmec Ltd
Allied Electronics Ltd
Appleby & Ireland Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
CNS Instruments Ltd
Cuthbert Ltd, Ralph
Elcontrol Ltd
Electrothermal Engineering Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Falk & Co Ltd, M.
Foster Instrument Co Ltd
General Electric Co Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Isopad Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Negretti & Zambra Ltd
Pye Ltd
Reavell & Co Ltd
Rotax Ltd
Savage & Parsons Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
Western Detail Mfrs Ltd
Wykeham Ltd

CONTROLLERS—VACUUM
★ Circle **No 678** on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
Cambridge Instrument Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fleischmann Ltd
Gordon & Co Ltd, James
Honeywell Controls Ltd
Hopkin & Co Ltd, F.
IV Pressure Controllers Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Milne Ltd, C. S.
Negretti & Zambra Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Salford Electrical Instruments Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Teddington Industrial Equipment Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

COUNTERS—BATCH
★ Circle **No 679** on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
British Northern Electrical Appliances Ltd
British Thomson-Houston Co Ltd, The
Ekco Electronics Ltd
Elcontrol Ltd
Ericsson Telephones Ltd
Guest Industrials Ltd
Labgear (Cambridge) Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Londex Ltd
McKellen Automation Ltd
Newmark Ltd
Pye Ltd
Racal Engineering Ltd
Rank Cintel Ltd
Spembly Ltd
Stonebridge Electrical Co Ltd
Trumeter Co Ltd
Venner Ltd

COUNTERS—GEIGER-MULLER (tubes)
★ Circle **No 680** on reply card
Ekco Electronics Ltd
Falk & Co Ltd, M.
General Electric Co Ltd, The
General Radiological Ltd
Mullard Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
20th Century Electronics Ltd

COUNTERS—MECHANICAL
★ Circle **No 681** on reply card
Carter & Co Ltd, B. & F.
Counting Instruments Ltd
Ericsson Telephones Ltd
Glass Developments Ltd
Guest Industrials Ltd
Leland Instruments Ltd
Londex Ltd
McKellen Automation Ltd
Panax Equipment Ltd
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stonebridge Electrical Co Ltd
Weyers Bros Ltd

COUNTERS—REVOLUTION
★ Circle **No 682** on reply card
Airmec Ltd
Allied Electronics Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Burndept Ltd
Carter & Co Ltd, B. & F.
Counting Instruments Ltd
EMI Electronics Ltd
Guest Industrials Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Pye Ltd
Rank Cintel Ltd
Smiths Industrial Instruments Ltd
Solartron Electronic Group Ltd
Stonebridge Electrical Co Ltd
20th Century Electronics Ltd
Weyers Bros Ltd

COUNTERS—SCINTILLATION
★ Circle **No 683** on reply card
B & K Laboratories Ltd
Burndept Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mervyn Instruments
Nuclear Enterprises Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

COUNTING EQUIPMENT (see **Ratemeters, Scalers**)

DENSITOMETERS—FILM BADGE
★ Circle **No 684** on reply card
Baldwin Instrument Co Ltd
Evans Electroselenium Ltd
Ilford Ltd
Joyce, Loebl & Co Ltd
Lock & Co Ltd, A. M.

DETECTORS—LEAK
★ Circle **No 685** on reply card
British Thomson-Houston Co Ltd, The
Edwards High Vacuum Ltd
Ekco Electronics Ltd
Elliott Bros (London) Ltd
Ferranti Ltd
General Electric Co Ltd, The
Infra-Red Development Co Ltd, The
Leybold Vacuum Sales Ltd
Livingston Laboratories Ltd
NGN Electrical Ltd
Sunvic Controls Ltd
20th Century Electronics Ltd

DISCRIMINATOR UNITS
★ Circle **No 686** on reply card
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Labgear Ltd
Lock & Co Ltd, A. M.

DISTILLATION APPARATUS
★ Circle **No 687** on reply card
Baird & Tatlock (London) Ltd
Bennett Sons & Shears Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
Glass Developments Ltd
Griffin & George Ltd
Laboratory Apparatus & Glass Blowing Co Ltd
Loughborough Glass Co Ltd
Manesty Machines Ltd
Permutit Co Ltd, The
Quickfit & Quartz Ltd
QVF Ltd
Scientific Furnishings Ltd
Springham & Co, G.
Stainless Steel Vessels (London) Ltd
Thermal Syndicate Ltd, The
Towers & Co Ltd, J. W.

DOORS—HEAVY SHIELDING (*See Section J*)

DOSERATE METERS
★ Circle **No 688** on reply card
Baldwin Instruments Co Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd

DOSIMETER CHARGING UNITS
★ Circle **No 689** on reply card
Baldwin Instrument Co Ltd
Dowty Nucleonics Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd

DOSIMETER CHARGING UNITS—*continued*
Falk & Co Ltd, M.
Gammax Ltd
General Radiological Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Plessey Nucleonics Ltd
Radiatron Ltd
Rank Cintel Ltd
Solus-Schall Ltd
Stephen & Co Ltd, R. A.

DOSIMETERS—QUARTZ FIBRE
★ Circle **No 690** on reply card
Baldwin Instrument Co Ltd
Elliott Brothers (London) Ltd
Falk & Co Ltd, M.
Gamma-Rays Ltd
Gammax Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Mullard Equipment Ltd
Radiatron Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Solus-Schall Ltd
Stephen & Co Ltd, R. A.

DRUMS—WASTE DISPOSAL
★ Circle **No 691** on reply card
Harris (Birmingham) Ltd, F. & R. M.
Reads Ltd
Robertson & Ferguson Ltd
Western Detail Mfrs Ltd

DRY BOXES (*See Glove Boxes*)

ELECTROMETERS—VIBRATING REED
★ Circle **No 692** on reply card
Ekco Electronics Ltd
Electronic Instruments Ltd
Ericsson Telephones Ltd
Kent Ltd, George
Mullard Ltd
Richmond Instrument Co Ltd

ELECTROMAGNETS
★ Circle **No 693** on reply card
Allen & Co Ltd, Edgar
Ayling Nuclear Equipment Co
B & K Laboratories Ltd
Electro Methods Ltd
English Steel Corporation Ltd
General Electric Co Ltd, The
Hendrey Relays Ltd
Magnetic Equipment Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Microwave Instruments Ltd
Mullard Ltd
Newport Instruments Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Westool Ltd

FILTERS—AIR (*See Section 1*)

FILTERS—CERAMIC
★ Circle **No 694** on reply card
Aerox Ltd
APV Co Ltd, The
Baird & Tatlock (London) Ltd
Bayley Clanahan Ltd
Cuthbert Ltd, Ralph
Doulton Industrial Porcelains Ltd
Laboratory Apparatus & Glass Blowing Co
Sintered Products Ltd
Thermal Syndicate Ltd, The (Fused Silica)
Vokes Ltd
Williams & James (Engineers) Ltd

FILTERS—CHEMICAL
★ Circle **No 695** on reply card
Aerox Ltd
APV Ltd
Baird & Tatlock (London) Ltd
Carlson Ltd, John D.
Cuthbert Ltd, Ralph
Doulton Laboratory Porcelains Ltd
Endecotts (Filters) Ltd
Extrudex Ltd
Hathernware Ltd
Laboratory Apparatus & Glass Blowing Co
Philips Electrical Ltd (Magnetic)
Quickfit & Quartz Ltd
Rediweld Ltd
Sharples Centrifuges Ltd
Sintered Products Ltd
Western Detail Mfrs Ltd

FILTERS—POROUS METAL
★ Circle **No 696** on reply card
Firkins Ltd, G. & A.
Hindle & Sons Ltd, Joshua
Metal & Plastic Compacts Ltd (Stainless Steel, Cupronickel Alloys)
Norgren Ltd., C. A.
Palatine Tool & Engineering Co (Surbiton) Ltd
Sintered Products Ltd

FILTERS—SINTERED GLASS
★ Circle **No 697** on reply card
Baird & Tatlock (London) Ltd
Brinkman Ltd, E.
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Jobling & Co Ltd, James
Loughborough Glass Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Quickfit & Quartz, Ltd
QVF Ltd
Towers & Co Ltd, J. W.

FISSION CHAMBERS
★ Circle **No 698** on reply card
Ekco Electronics Ltd
Plessey Nucleonics Ltd
20th Century Electronics Ltd

FLAW DETECTORS—MAGNETIC
★ Circle **No 699** on reply card
Babcock & Wilcox Ltd
Falk & Co Ltd, M.
Gammax Ltd
General Electric Co Ltd, The
General Radiological Ltd
Glass Developments Ltd
Lancashire Dynamo Electronic Products Ltd
Magnetic Equipment Co Ltd, The
Metropolitan-Vickers Electrical Co Ltd
Philips Electrical Ltd
Smith, R. Fraser

FLAW DETECTORS—ULTRASONIC
★ Circle **No 700** on reply card
Babcock & Wilcox Ltd
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Dawe Instruments Ltd
Falk & Co Ltd, M.
General Electric Co Ltd, The
Glass Developments Ltd
Kelvin & Hughes (Industrial) Ltd
Livingston Laboratories Ltd
Solus-Schall Ltd
Ultrasonics Ltd
Ultrasonoscope Ltd

FLOW METERS—GAS
★ Circle **No 701** on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Dowty Nucleonics Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Gallenkamp & Co Ltd, A.
Gordon & Co Ltd, James
Griffin & George Ltd
Honeywell Controls Ltd
Hopkin & Co Ltd, F.
Hutcheon Duthie & Son Ltd, R.
Kent, Ltd, George
Metropolitan-Vickers Electrical Co Ltd
Milne Ltd, C. S.
Parkinson & Cowan Ltd
Quickfit & Quartz Ltd
QVF Ltd
Rotameter Manufacturing Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Taylor Controls Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Wykeham Ltd

FLOW METERS—LIQUID
★ Circle **No 702** on reply card
Alto Instruments (GB) Ltd
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Dowty Nucleonics Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Firth Cleveland Instruments Ltd
Gallenkamp & Co Ltd, A.
Glenfield & Kennedy Ltd
Gloster Technical Developments Ltd
Gordon & Co Ltd, James
Griffin & George Ltd
Hindle & Sons Ltd, Joshua
Honeywell Controls Ltd
Hopkin & Co Ltd, F.
Integral Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Liquid Systems Ltd
Measurement Ltd
Monitor Patent Safety Devices Ltd
Parkinson & Cowan Ltd
QVF Ltd
Rotameter Manufacturing Co Ltd
Ryder & Co (Manchester) Ltd, Thomas
Shandon Scientific Co Ltd
Simmonds Aerocessories Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Tylors of London Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Wykeham Ltd

FLOW METERS—LIQUID METAL
★ Circle **No 703** on reply card
Alto Instruments (GB) Ltd
Appleby & Ireland Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Ryder & Co (Manchester) Ltd, Thomas
Thermocontrol Installations Co Ltd

FLUORIMETERS
★ Circle **No 704** on reply card
Baird & Tatlock (London) Ltd
Evans Electroselenium Ltd
Griffin & George Ltd
Joyce, Loebl Ltd

FLUX SCANNING APPARATUS
★ Circle **No 705** on reply card
Chatwood-Milner Ltd
Elliott Nucleonics Ltd
General Radiological Ltd
Hawker Siddeley Nuclear Power Ltd
Ormiston Ltd
Plessey Nucleonics Ltd
Sunvic Controls Ltd

FUME CUPBOARDS
★ Circle **No 706** on reply card
Baird & Tatlock (London) Ltd
Bullows & Sons Ltd, Alfred
Controlled Heat & Air Ltd
Cyenet Joinery Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hathernware Ltd
Hospital & Laboratory Supplies Ltd
Mancuna Engineering Ltd
Marine & Industrial Plastics Ltd
Mathews & Yates Ltd
North of England School Furnishing Co Ltd
Opperman Ltd, S. E.
Owen Power Plant Co
Rediweld Ltd
Scientific Furnishings Ltd
Supervents Ltd
Towers & Co Ltd, J. W.
Tupholme & Co Ltd, George E.
Visco Engineering Co Ltd
Weatherfoil Heating Systems Ltd

FURNACES—CRUCIBLE
★ Circle **No 707** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Head Wrightson Processes Ltd
Johnson, Matthey & Co Ltd
Morgan Crucible Co Ltd, The
River Chemical Co Ltd
Scientific Furnishings Ltd
Towers & Co Ltd, J. W.

FURNACES—MUFFLE
★ Circle **No 708** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Carborundum Co Ltd, The
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Glass Developments Ltd
Griffin & George Ltd
Johnson, Matthey & Co Ltd
River Chemical Co Ltd
Scientific Furnishings Ltd
Spembly Ltd
Towers & Co Ltd, J. W

FURNACES—TUBE
★ Circle **No 709** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Catterson-Smith Ltd, R. M.
Cuthbert Ltd, Ralph
Electric Furnace Co Ltd
Electrothermal Engineering Ltd
Engelhardt (Baker Platinum) (tubes)
Farmer & Son Ltd
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Head Wrightson Processes Ltd
Johnson, Matthey & Co Ltd
River Chemical Co Ltd
Scientific Instruments Ltd
Spembly Ltd
Towers & Co Ltd, J. W.

FURNACES—VACUUM
★ Circle **No 710** on reply card
AEW Ltd
Bayley Clanahan Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Electric Furnace Co Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Spembly Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

GAS SAMPLING PLANT
(*burst slug detection*)
★ Circle **No 711** on reply card
Armstrong Siddeley Motors Ltd
Dowty Nucleonics Ltd
Elliott Nucleonics Ltd
General Radiological Ltd
Plessey Nucleonics Ltd
Sunvic Controls Ltd

GAUGES—DIFFERENTIAL PRESSURE
★ Circle **No 712** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Barnet Instruments Ltd
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Dewrance & Co Ltd
Darton & Co Ltd, F.
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Gordon & Co Ltd, James
Honeywell Controls Ltd
Hopkinsons Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

GAUGES—IONIZATION
★ Circle **No 713** on reply card
Appleby & Ireland Ltd
Edwards High Vacuum Ltd
Electronic Instruments Ltd
Fleischmann (London) Ltd
Isotope Developments Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Siemens Edison Swan Ltd
Vacuum Industrial Applications Ltd

GAUGES—LIQUID LEVEL NUCLEONIC
★ Circle **No 714** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Dewrance & Co Ltd
Ekco Electronics Ltd
Firth Cleveland Instruments Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
KDG Instruments Ltd
Lock & Co Ltd, A. M.
Salford Electrical Instruments Ltd
Smiths Industrial Instruments Ltd
Sunvic Controls Ltd
Thompson Instrument Co Ltd, John

GAUGES—LIQUID LEVEL (OTHER)
★ Circle **No 715** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Butterworth Bros Ltd
British Steam Specialties Ltd
Elcontrol Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
General Radiological Ltd
Gordon & Co Ltd, James
Hindle & Sons Ltd, Joshua
Hobson Ltd, H. M.
Honeywell Controls Ltd
Ionic Instruments (London) Ltd
KDG Instruments Ltd
Kent Ltd, George
Klinger Ltd, Richard
Lancashire Dynamo Electrical Products Ltd
Lock & Co Ltd, A. M.
Negretti & Zambra Ltd
Rotameter Manufacturing Co Ltd
Salford Electrical Instruments Ltd
Simmonds Aerocessories Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Whessoe Ltd
Thompson Instrument Co Ltd, John
Wykeham Ltd

GAUGES—PRESSURE
★ Circle **No 716** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Barnet Instruments Ltd
British Rototherm Co Ltd, The
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Fielden Electronics Ltd
Fleischmann (London) Ltd
Gordon & Co Ltd, James
Guest Industrials Ltd
Hobson Ltd, H. M.
Honeywell Controls Ltd
Hopkinsons Ltd
KDG Instruments Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd (Moving Coil)
Sangamo Weston Ltd
Savage & Parsons Ltd
Shandon Scientific Co Ltd
Smith Industrial Instruments Ltd
Solartron Electronic Group Ltd
Stewart Aeronautical Ltd
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
Wykeham Ltd

GAUGES—STRAIN
★ Circle **No 717** on reply card
Appleby & Ireland Ltd
Elliott Brothers (London) Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Honeywell Controls Ltd
Kelvin & Hughes (Industrial) Ltd
Leland Instruments Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Savage & Parsons Ltd
Saunders-Roe Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Technograph Ltd
Teddington Industrial Equipment Ltd
Tinsley & Co Ltd, H.

GAUGES—THICKNESS OR DENSITY NUCLEONIC
★ Circle **No 718** on reply card
Appleby & Ireland Ltd
Baldwin Instrument Co Ltd
Davy & United Engineering Co Ltd
Dawe Instruments Ltd
Ekco Electronics Ltd
Isotope Developments Ltd
Kelvin & Hughes (Industrial) Ltd
Lock & Co Ltd, A. M.
Philips Electrical Ltd
Vernon Instrument Ltd

GAUGES VACUUM
★ Circle **No 719** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Barnet Instruments Ltd
British Rototherm Co Ltd, The
British Steam Specialties Ltd
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Glass Developments Ltd
Honeywell Controls Ltd
KDG Instruments Ltd
Kent Ltd George
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Negretti & Zambra Ltd
NGN Electrical Ltd
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd
Smiths Industrial Instruments Ltd
Stewart Aeronautical Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Vacuum Industrial Applications Ltd

GAUGES—WATER
★ Circle **No 720** on reply card
Accurate Recording Instrument Co Ltd
Appleby & Ireland Ltd
Babcock & Wilcox Ltd
Barnet Instruments Ltd
British Steam Specialties Ltd
Butterworth Bros Ltd
Darton & Co Ltd, F.
Dewrance & Co Ltd
Elliott Brothers (London) Ltd
Gordon & Co Ltd, James
Honeywell Controls Ltd
Hopkinsons Ltd
KDG Instruments Ltd
Kent Ltd. George
Klinger Ltd, Richard
Payne & Griffiths Ltd
Salford Electrical Instruments Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John

GEIGER-MULLER TUBES—
(See Counters—Geiger-Müller)

GENERATORS—HIGH FREQUENCY
★ Circle **No 721** on reply card
Airmec Ltd
British Physical Laboratories
Holiday & Hemmerdinger Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Newton Victor Ltd
Redifon Ltd
Research & Control Instruments Ltd
Standard Telephones & Cables Ltd

GENERATORS—PULSE
★ Circle **No 722** on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
British Physical Laboratories
Cawkell Research & Electronics Ltd
Dynatron Radio Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
General Electric Co Ltd, The
Ferranti Ltd
Fleming Radio (Developments) Ltd
General Radiological Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude (agents for General Radio Co USA)
Mullard Equipment Ltd
Nagard Ltd
Newton Victor Ltd
Panax Equipment Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd
Solartron Electronic Group Ltd
Wayne Kerr Laboratories Ltd
Western Detail Mfrs Ltd

GENERATORS—SAW TOOTH
★ Circle **No 723** on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
General Radiological Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Mullard Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd

GENERATORS—SQUARE WAVE
★ Circle **No 724** on reply card
Allied Electronics Ltd
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
EMI Electronics Ltd
General Radiological Ltd
Glass Developments Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lyons Ltd, Claude
Microwave Instruments Ltd
Mullard Ltd
Nagard Ltd
Panax Equipment Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Servomex Controls Ltd
Solartron Electronic Group Ltd
Venner Electronics Ltd

GENERATORS—ULTRASONIC
★ Circle **No 725** on reply card
B & K Laboratories Ltd
Cawkell Research & Electronics Ltd
General Radiological Ltd
Glass Developments Ltd
Kelvin & Hughes Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Mullard Equipment Ltd
Solartron Electronic Group Ltd
Ultrasonics Ltd
Ultrasonoscope Ltd

GENERATORS—ELECTROSTATIC
★ Circle **No 726** on reply card
High Voltage Servicing Co Ltd (sole UK distributors for HVE Corpn USA)
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Miles Hivolt Ltd
Research & Control Instruments Ltd (Cockcroft-Walton)

GLASS—LEAD
★ Circle **No 727** on reply card
Andrews, Cuthbert
Butterworth Bros Ltd
Chance Bros Ltd
Chance-Pilkington Optical Works
Laboratory Apparatus & Glass Blowing Co
Metropolitan-Vickers Electrical Co Ltd
Newton Victor Ltd
Optical Works Ltd, The
QVF Ltd
Research & Control Instruments Ltd
Savage & Parsons Ltd

GLASSWARE—LABORATORY
★ Circle **No 728** on reply card
Baird & Tatlock (London) Ltd
Brinkmann Ltd, E.
Butterworth Bros Ltd
Chance Bros Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
General Radiological Ltd
Glass Developments Ltd
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Ionic Instruments (London) Ltd
Jobling & Co Ltd, James
Laboratory Apparatus & Glass Blowing Co
Loughborough Glass Co Ltd
Poulten, Seife & Lee Ltd
Quickfit & Quartz Ltd
QVF Ltd
River Chemical Co Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Springham & Co, G.
Towers & Co Ltd, J. W.
Vicsons Ltd

GLOVE BOXES—STANDARD PRODUCTS
★ Circle **No 729** on reply card
Ayling Nuclear Equipment Co
BMB (Sales) Ltd
Chatwood-Milner Ltd
Dore Ltd
Falk & Co Ltd, M.
HL Instruments Ltd
Hawker Siddeley Nuclear Power Ltd
Marine & Industrial Plastics Ltd
Mendip (Chemical Engineering) Ltd
Ramsey Engineering Co Ltd
Savage & Parsons Ltd
South London Electrical Equipment Co Ltd
Towers & Co Ltd, J. W.
Townson & Mercer Ltd
Weatherfoil Heating Systems Ltd

GLOVE BOXES—SPECIAL ORDER
★ Circle **No 730** on reply card
Ayling Nuclear Equipment Co
BMB (Sales) Ltd
Boucher & Co Ltd
Brown & Co Ltd, E. G.
Carrier Engineering Co Ltd
Chatwood-Milner Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Graviner Mfg Co Ltd
Guest Industrials Ltd
Hawker Siddeley Nuclear Power Ltd
HL Instruments Ltd
Marine & Industrial Plastics Ltd
Mendip (Chem. Eng.) Ltd
Opperman Ltd, S. E.
Palatine Tool & Engineering Co (Surbiton) Ltd
Savage & Parsons Ltd
South London Electrical Equipment Co Ltd
Spembly Ltd
Thermo-Plastics Ltd
Townson & Mercer Ltd
Vickers-Armstrongs Ltd
Weatherfoil Heating Systems Ltd
Western Detail Mfrs Ltd

GLOVE BOX GAUNTLETS
★ Circle **No 731** on reply card
Chichester Rubber Co Ltd, The
Falk & Co Ltd, M.
Milne Ltd, C. S.
South London Electrical Equipment Co Ltd
Towers & Co Ltd, J. W.
Veedip Ltd

HARDNESS TESTING INSTRUMENTS
★ Circle **No 732** on reply card
Nash & Thompson Ltd
Shandon Scientific Co Ltd
Wykeham Ltd

HEATERS—RADIOFREQUENCY
★ Circle **No 733** on reply card
B & K Laboratories Ltd
British Thomson-Houston Co Ltd, The
EMI Electronics Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Incandescent Heat Co Ltd
Isopad Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Metalectric Furnaces Ltd
Metropolitan-Vickers Electrical Co Ltd
Radio Heaters Ltd
Western Detail Mfrs Ltd

HEATERS—SURFACE
★ Circle **No 734** on reply card
Dore Ltd, J.
Electrothermal Engineering Ltd
Isopad Ltd
Spembly Ltd
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.
Worthington-Simpson Ltd

HEATING TAPES
★ Circle **No 735** on reply card
Baird & Tatlock (London) Ltd
Electrothermal Engineering Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Hospital & Laboratory Supplies Ltd
Isopad Ltd
Laboratory Apparatus & Glass Blowing Co
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.
Vicsons Ltd

INTROSCOPES
★ Circle **No 736** on reply card
Allen & Co, P. W.
Foster Instrument Co Ltd
Optical Works Ltd

IONIZATION CHAMBERS
★ Circle **No 737** on reply card
Baldwin Instrument Co Ltd
Gammax Ltd
General Radiological Ltd
Isotope Developments Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
Tinsley & Co Ltd, H.
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
20th Century Electronics Ltd

IONIZATION CHAMBERS—REACTOR
★ Circle **No 738** on reply card
General Radiological Ltd
Isotope Developments Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd
20th Century Electronics Ltd
Vacuum Industrial Applications Ltd

IRRADIATION SERVICES
★ Circle **No 739** on reply card
Metropolitan-Vickers Electrical Co Ltd
Nuclear Engineering Ltd
Rubery Owen Ltd (Darlaston)
TI Nuclear Engineering Ltd

ISOTOPES
★ Circle **No 740** on reply card
Falk & Co Ltd, M. (agents)
Radiochemical Centre (UKAEA)
20th Century Electronics Ltd

ISOTOPE CONTAINERS—*(See Containers—Isotope)*

KICKSORTERS—*(See Analysers—Pulse Amplitude)*

LABORATORY EQUIPMENT CONTRACTORS
★ Circle **No 741** on reply card
Allied Electronics Ltd (electronic)
Baird & Tatlock (London) Ltd
Barytes (Shielding Products) Ltd
Cuthbert Ltd, Ralph
Cyvnet Joinery Ltd
Dynatron Radio Ltd
Electrothermal Engineering Ltd
Engis Ltd (Diamond Abrasive Mfrs)
Extrudex Ltd
Falk & Co Ltd, M.
Gallenkamp & Co Ltd, A.
Gardner & Co Ltd, Henry
Griffin & George Ltd
Harris (Birmingham) Ltd, F. & R. M.
Hospital & Laboratory Supplies Ltd
Ionic Instruments (London) Ltd
Isotope Developments Ltd
Laboratory Apparatus & Glass Blowing Co
Lang London Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Loughborough Glass Co Ltd
Marine & Industrial Plastics Ltd
Microwave Instruments Ltd
North of England School Furnishing Co Ltd
QVF Ltd
Pye Ltd
Rediweld Ltd
Scientific Furnishings Ltd
Solartron Electronic Group Ltd
Spembly Ltd
Stabilag Co Ltd, The
Sturtevant Engineering Co Ltd
Tinsley & Co Ltd, H.
Towers & Co Ltd, J. W.
Townson & Mercer Ltd
Vicsons Ltd
Western Detail Mfrs Ltd

LEAD BLOCKS
★ Circle **No 742** on reply card
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd
Blundell & Crompton Ltd
British Lead Mills Ltd
Ekco Electronics Ltd
ERD Engineering Co Ltd
Falk & Co Ltd, M.
Fowler Ltd
General Radiological Ltd
Grazebrook Ltd, M. & W.
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Co Ltd
Nuclear Engineering Ltd
Randall Ltd, P. E.
Research & Control Instruments Ltd
Roberts Ltd, R. E.
Savage & Parsons Ltd
Western Detail Mfrs Ltd

LEAD CASTLES
★ Circle **No 743** on reply card
Appleton & Howard Ltd
Associated Lead Manufacturers Ltd
British Lead Mills Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
ERD Engineering Co Ltd
Fowler Ltd
General Radiological Ltd
Grey & Marten Ltd
Hull & Sons Ltd, F.
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Mills Packard Construction Co Ltd
Nuclear Engineering Ltd
Panax Equipment Ltd
Randall Ltd, P. E.
Research & Control Instruments Ltd
Roberts Ltd, R. E.
Savage & Parsons Ltd
Western Detail Mfrs Ltd

LIGHT SOURCES—SPECTROGRAPHIC
★ Circle **No 744** on reply card
British Thomson-Houston Co Ltd
Cuthbert Ltd, Ralph
Hilger & Watts Ltd
Joyce, Loebl Ltd
Leland Instruments Ltd
Philips Electrical Ltd

LIGHT SOURCES—ULTRAVIOLET
★ Circle **No 745** on reply card
Fleischmann (London) Ltd
General Electric Co Ltd, The
Hanovia Lamps
Joyce, Loebl Ltd
Research & Control Instruments Ltd
Thermal Syndicate Ltd

LOAD CELLS
★ Circle **No 746** on reply card
B. & K Laboratories Ltd
Davy & United Engineering Co Ltd
Elliott Bros (London) Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Wykeham Ltd

MAGNETS—PERMANENT
★ Circle **No 747** on reply card
Allen & Co Ltd, Edgar
Darwins Ltd
English Steel Corp Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Magnetic Equipment Co Ltd, The
Mullard Ltd
Plessey Ltd
Research & Control Instruments Ltd

MAGNETS—ELECTRO (see **Electromagnets**)

MANIPULATORS—MASTER SLAVE
★ Circle **No 748** on reply card
Hobson Ltd, H. M.
General Electric Co Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pye Ltd
Savage & Parsons Ltd
Western Detail Mfrs Ltd

MANIPULATORS—TONG
★ Circle **No 749** on reply card
Carter & Viner Ltd
General Radiological Ltd
HL Instruments Ltd
Laboratory Apparatus & Glass Blowing Co
Savage & Parsons Ltd
Teleflex Products Ltd
Townson & Mercer Ltd
Western Detail Mfrs Ltd

MANOMETERS—ELECTRONIC
★ Circle **No 750** on reply card
Appleby & Ireland Ltd
Bryans Aeroquipment Ltd
Cambridge Instrument Co Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
Solartron Electronic Group Ltd

MANOMETERS—INCLINED TUBE
★ Circle **No 751** on reply card
Appleby & Ireland Ltd
Bryans Aeroquipment Ltd
Casella & Co Ltd, C. F.
Darton & Co Ltd, F.
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MANOMETERS—MERCURY
★ Circle **No 752** on reply card
Appleby & Ireland Ltd
Barnet Instruments Ltd
Bryans Aeroquipment Ltd
Budworth Ltd, David
Darton & Co Ltd, F.
Edwards High Vacuum Ltd
Elliott Brothers (London) Ltd
Evershed & Vignoles Ltd
Gallenkamp & Co Ltd, A.
Glass Developments Ltd
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
Quickfit & Quartz Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MANOMETERS—U-TUBE
★ Circle **No 753** on reply card
Appleby & Ireland Ltd
Baird & Tatlock (London) Ltd
Bryans Aeroquipment Ltd
Budworth Ltd, David
Casella & Co Ltd, C. F.
Cuthbert Ltd, Ralph
Darton & Co Ltd, F.
Edwards High Vacuum Ltd
Elliott Brothers (London) Ltd
Gallenkamp & Co Ltd, A.
Glass Developments Ltd
Griffin & George Ltd
Ionic Instruments (London) Ltd
Kent Ltd, George
Leybold Vacuum Sales Ltd
Negretti & Zambra Ltd
Quickfit & Quartz Ltd
QVF Ltd
Springham & Co, G.
Thompson Instrument Co Ltd, John
Towers & Co Ltd, J. W.

MECHANICAL TESTING EQUIPMENT
★ Circle **No 754** on reply card
Avery Ltd, W. & T.
Cawkell Research & Electronics Ltd
Denison & Son Ltd, Samuel
Dexion Ltd
Electro-Hydraulics Ltd
EMI Electronics Ltd
Ionic Instruments (London) Ltd
Mercer Ltd, T.
Moore & Co Ltd, W. & E.
Rubery Owen Ltd (Darlaston)
Scaley Engineering Ltd
Tensometer Ltd
Universal Pattern & Precision Eng Co Ltd
Weyers Bros Ltd
Wykeham Ltd

METERS—BTU
★ Circle **No 755** on reply card
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Hutcheon Duthie & Son Ltd, R.
Kent Ltd, George
Thermocontrol Installations Co Ltd

METERS—FREQUENCY
★ Circle **No 756** on reply card
Airmec Ltd
British Physical Laboratories
Elliott Bros (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Ferranti Ltd
General Electric Co Ltd, The
Honeywell Controls Ltd
Kent Ltd, George
Lyons Ltd, Claude
Measuring Instruments (Pullin) Ltd
Racal Engineering Ltd
Record Electrical Co Ltd, The
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Stonebridge Electrical Co Ltd
Turner Ltd, E.
Venner Ltd

METERS—GAS
★ Circle **No 757** on reply card
Baird & Tatlock (London) Ltd
Griffin & George Ltd
Guest Industrials Ltd
Honeywell Controls Ltd
Kent Ltd, George
Parkinson & Cowan Ltd
White Electrical Instrument Co Ltd
Wright & Co Ltd, Alexander

METERS—HUMIDITY
★ Circle **No 758** on reply card
Cambridge Instrument Co Ltd
Darton & Co Ltd, F.
Dawe Instruments Ltd
Elliott Bros (London) Ltd
Honeywell Controls Ltd
Research & Control Instruments Ltd
Taylor-Short & Mason Ltd

METERS—pH
★ Circle **No 759** on reply card
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Doran Instrument Co Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Honeywell Controls Ltd
Ionic Instruments (London) Ltd

METERS—pH—*continued*
Kent Ltd, George
Lock & Co Ltd, A. M.
McKellen Automation Ltd
Research & Control Instruments Ltd
White Electrical Instrument Co Ltd
Wykeham Ltd

METERS—POWER FACTOR
★ Circle **No 760** on reply card
British Thomson-Houston Co Ltd, The
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
Kent Ltd, George
McKellen Automation Ltd
Measuring Instruments (Pullin) Ltd
Measurement Ltd
Metropolitan-Vickers Electrical Co Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Salford Electrical Instruments Ltd

METERS—REACTOR PERIOD
★ Circle **No 761** on reply card
Ekco Electronics Ltd
Elliott Nucleonics Ltd
General Radiological Ltd
Honeywell Controls Ltd
Isotope Developments Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Sunvic Controls Ltd

METERS—REACTOR POWER LEVEL
★ Circle **No 762** on reply card
Ekco Electronics Ltd
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Honeywell Controls Ltd
Isotope Developments Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Record Electrical Co Ltd, The
Sunvic Ltd

METERS—REACTOR POWER ERROR
★ Circle **No 763** on reply card
Ekco Electronics Ltd
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Honeywell Controls Ltd
Kent Ltd, George
Plessey Nucleonics Ltd
Record Electrical Ltd
Sunvic Controls Ltd

METERS—kWh
★ Circle **No 764** on reply card
Elliott Nucleonics Ltd
English Electric Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
Kent Ltd, George
Measurement Ltd
Metropolitan-Vickers Electrical Co Ltd
Parkinson & Cowan Ltd
Stonebridge Electrical Co Ltd

MICROSCOPES—ELECTRON
★ Circle **No 765** on reply card
Baker of Holborn Ltd, C.
Cuthbert Ltd, Ralph
Metropolitan-Vickers Electrical Co Ltd
Research & Control Instruments Ltd
Stonebridge Electrical Co Ltd
Wykeham Ltd

MICROSCOPES—FLYING SPOT
★ Circle **No 766** on reply card
McKellen Automation Ltd
Rank Cintel Ltd

MICROSCOPES—MEASURING
★ Circle **No 767** on reply card
Baker of Holborn Ltd, C.
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Griffin & George Ltd
Hilger & Watts Ltd
McArthur Microscopes Ltd
Precision Tool & Instrument Ltd
Prior & Co Ltd, W. R.
Shandon Scientific Co Ltd
Wykeham Ltd

MICROSCOPES—METALLURGICAL
★ Circle **No 768** on reply card
Baker of Holborn Ltd, C.
Cooke, Troughton & Simms Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
McArthur Microscopes Ltd
Prior & Co Ltd, W. R.
Shandon Scientific Co Ltd
Wykeham Ltd

MICROSCOPES—PROJECTION
★ Circle **No 769** on reply card
Baker of Holborn Ltd, C.
Cooke, Troughton & Simms Ltd
Cuthbert Ltd, Ralph
Flatters & Garnett Ltd
McArthur Microscopes Ltd
Shandon Scientific Co Ltd

MONITORS—FAST NEUTRON
★ Circle **No 770** on reply card
Burndept Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Nuclear Enterprises (GB) Ltd
Plessey Nucleonics Ltd
20th Century Electronics Ltd

MONITORS—HAND, FOOT & CLOTHING
★ Circle **No 771** on reply card
EMI Electronics Ltd
Isotope Development Ltd
Leland Instruments Ltd
Mullard Equipment Ltd (hand)
Panax Equipment Ltd
Research & Control Instruments Ltd

MONITORS—PORTABLE RADIATION
★ Circle **No 772** on reply card
Airmec Ltd
Baldwin Instrument Co Ltd
Burndept Ltd
Ekco Electronics Ltd
Elliott Brothers (London) Ltd
Ericsson Telephones Ltd
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nicholson (Scientific Instruments) Ltd, W. B.
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Radiation Monitors Ltd
Research & Control Instruments Ltd

MONITORS—X-RAY
★ Circle **No 773** on reply card
Baldwin Instrument Co Ltd
Ekco Electronics Ltd
Fleming Radio (Developments) Ltd
Gamma-Rays Ltd
General Radiological Ltd
Labgear Ltd
Research & Control Instruments Ltd
Solus-Schall Ltd

MOTORS—FRACTIONAL H.P.
★ Circle **No 774** on reply card
ASEA Electric Ltd
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd
Cuthbert Ltd, Ralph
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
English Electric Co Ltd, The
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Jones & Stevens Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Klaxon Ltd
Lancashire Dynamo & Crypto Ltd
Laurence, Scott & Electromotors Ltd
McKellen Automation Ltd
Metropolitan-Vickers Electrical Co Ltd
Newman Industries Ltd
Plessey Nucleonics Ltd
Pringle & Sons (London) Ltd, Robert
Pullin & Co Ltd, R. B.
Rotax Ltd
Stewart Aeronautical Ltd
Thermocontrol Installations Co Ltd

MOTORS—SERVO
★ Circle **No 775** on reply card
British Thomson-Houston Co Ltd, The
Electro Methods Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Gordon & Co Ltd, James
Jones & Co (Engineers) Ltd, Walter
Jones & Stevens Ltd
Kent Ltd, George
Ketay Ltd
Klaxon Ltd
Lancashire Dynamo Electronic Products Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Nucleonics Ltd
Pullin & Co Ltd, R. B.
Stewart Aeronautical Ltd
Thermocontrol Installations Co Ltd

MOTORS—SYNCHRONOUS
★ Circle **No 776** on reply card
ASEA Electrical Ltd
British Thomson-Houston Co Ltd, The
Crompton Parkinson Ltd
Electric Construction Co Ltd, The
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
English Electric Co Ltd, The
General Electric Co Ltd, The
Jones & Co (Engineers) Ltd, Walter
Kelvin & Hughes Ltd
Kent Ltd, George
Klaxon Ltd
Lancashire Dynamo & Crypto Ltd
Laurence, Scott & Electromotors Ltd
Metropolitan-Vickers Electrical Co Ltd
Plessey Co Ltd, The
Pullin & Co Ltd, R. B.
Sangamo Weston Ltd
Stewart Aeronautical Ltd
Thermocontrol Installations Co Ltd

NAMEPLATES, DIALS AND SCALES
★ Circle **No 777** on reply card
British Metal Engraving Co Ltd
Caxton Nameplate Mfg Co Ltd
John Gosheron & Co Ltd
London Name Plate Mfg Co Ltd, The
McKenna & Moore Ltd
Metal Gravure Co Ltd
Reliance (Nameplates) Ltd
Universal Engraving Co Ltd

NEUTRON SOURCES
★ Circle **No 778** on reply card
Miles Hivolt Ltd
Radiochemical Centre (UKAEA)
Research & Control Instruments Ltd
Talbot Stead Tube Co Ltd
TI Nuclear Engineering Ltd

OSCILLOGRAPHS—CATHODE RAY
★ Circle **No 779** on reply card
Airmec Ltd
Allied Electronics Ltd
B & K Laboratories Ltd
British Physical Laboratories
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
EMI Electronics Ltd
Ferranti Ltd
Fleming Radio Ltd
Furzehill Laboratories Ltd
General Electric Co Ltd, The
Griffin & George Ltd
Holiday & Hemmerdinger Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Lyons Ltd, Claude (agents for Allen B Du Mont USA)
McKellen Automation Ltd
Mullard Equipment Ltd
Nagard Ltd
Parkinson & Cowan Ltd
Pye Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Robinson & Pinrs Ltd, F. C.
Solartron Electronic Group Ltd
Southern Instruments, Computer Division
Taylor Electrical Instruments Ltd
20th Century Electronics Ltd (cathode ray tubes)

OVENS—LABORATORY
★ Circle **No 780** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Bayley Clanahan Ltd
Cuthbert Ltd, Ralph
Gallenkamp & Co Ltd, A.
General Electric Co Ltd, The
Griffin & George Ltd
Harris (Birmingham) Ltd, F. & R. M.
Laboratory Apparatus & Glass Blowing Co
Leland Instruments Ltd
Lund Bros Ltd
Marine & Industrial Plastics Ltd
Royce Electric Furnaces Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Spembly Ltd
Towers & Co Ltd, J. W.

OVENS—VACUUM
★ Circle **No 781** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Barlow-Whitney Ltd
Bayley Clanahan Ltd
Blundell & Crompton Ltd
Butterfield Ltd, W. P.
Edwards High Vacuum Ltd
Foster Yates & Shaw Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Spembly Ltd
Towers & Co Ltd, J. W.
Vacuum Industrial Applications Ltd
Walker Ltd, C. & W.
Western Detail Mfrs Ltd

PANELS—INSTRUMENT
★ Circle **No 782** on reply card
Accurate Recording Instrument Co Ltd
Allied Electronics Ltd
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Ayling Nuclear Equipment Co
Brown & Co Ltd, E. G.
Constructors John Brown Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
General Radiological Ltd
Gordon & Co Ltd, James
Hendrey Relays Ltd
Honeywell Controls Ltd
Hutcheon Duthie & Son Ltd, R.
Integra, Leeds & Northrup Ltd
Ionic Instruments (London) Ltd
IV Pressure Controllers Ltd
KDG Instruments Ltd
Kent Ltd, George
Kelvin & Hughes Ltd
Laboratory Apparatus & Glass Blowing Co
Laurence, Scott & Electromotors Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Lund Bros Ltd
Metal Gravure Co Ltd, The
Microwave Instruments Ltd
Milne Ltd, C. S.
New Western (Engineering) Ltd
Permali Ltd
Reyrolle & Co Ltd, A.
Ryder & Co (Manchester) Ltd, Thomas
Salford Electrical Instruments Ltd
Sheet Metal Engineering Ltd
Southborough (Weybridge) Ltd
Spembly Ltd
Stabilag Co Ltd, The
Sunvic Controls Ltd
Taylor Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd
Thompson Instrument Co Ltd, John
West Instruments Ltd
Western Detail Mfrs Ltd

PATHOLOGICAL LABORATORY APPARATUS
★ Circle **No 783** on reply card
Baird & Tatlock (London) Ltd
Cuthbert Ltd, Ralph

PATHOLOGICAL LABORATORY APPARATUS *—continued*

Edwards High Vacuum Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Gurr Ltd, Edward
Hendrey Relays Ltd
Hospital & Laboratory Supplies Ltd
Lock & Co Ltd, A. M.
Loughborough Glass Co Ltd
Scientific Furnishings Ltd
Shandon Scientific Co Ltd
Stabilag Co Ltd, The
Towers & Co Ltd, J. W.
Weyers Bros Ltd

PERISCOPES
★ Circle **No 784** on reply card
Allen & Co, P. W.
Avimo Ltd
Foster Instrument Co Ltd
Optical Works Ltd
Ross Ensign Ltd
Spembly Ltd

PHOTOCELLS & DEVICES
★ Circle **No 785** on reply card
Aimee Ltd
Allied Electronics Ltd
Baldwin Instrument Co Ltd
British Thomson-Houston Co Ltd, The
Counting Instruments Ltd
Elcontrol Ltd
EMI Electronics Ltd
Evans Electroselenium Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Holiday & Hemmerdinger Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Megatron Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Ltd
Radiovisor Parent Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Sangamo Weston Ltd
Siemens Edison Swan Ltd
Spembly Ltd
Standard Telephones & Cables Ltd
Stonebridge Electrical Co Ltd

PHOTOGRAPHIC MATERIALS
★ Circle **No 786** on reply card
General Chemical & Pharmaceutical Co Ltd, The
Ilford Ltd
Kodak Ltd
Mason & Sons Ltd, E. N.
Research & Control Instruments Ltd
Stewart Aeronautical Ltd

PHOTOMULTIPLIER TUBES
★ Circle **No 787** on reply card
B. & K. Laboratories Ltd
EMI Electronics Ltd
ERD Engineering Co Ltd
Isotope Developments Ltd
Leland Instruments Ltd
Mullard Ltd
Rank Cintel Ltd
Reid Manufacturing Co Ltd, A.
Research & Control Instruments Ltd
Siemens Edison Swan Ltd
20th Century Electronics Ltd

POLAROGRAPHS
★ Circle **No 788** on reply card
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Evershed & Vignoles Ltd
Integra, Leeds & Northrup Ltd
Lock & Co Ltd, A. M.
Lyons Ltd, Claude (agents for General Radio Co USA)
Mervyn Instruments
Southern Instruments

POTENTIOMETERS
★ Circle **No 789** on reply card
Baird & Tatlock (London) Ltd
B. & K. Laboratories Ltd
Beckman Instruments Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Doran Instrument Co Ltd
Fox Ltd, P. X. (precision and power)
Geipel Ltd, William
General Electric Co Ltd, The
Griffin & George Ltd
Holiday & Hemmerdinger Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Isenthal & Co Ltd
Kent Ltd, George
Lock & Co Ltd, A. M.
Morganite Resistors Ltd
Plessey Co Ltd, The

PRE-AMPLIFIERS
★ Circle **No 790** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Cawkell Research & Electronics Ltd
Cossor Instruments Ltd
Ekco Electronics Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
Ericsson Telephones Ltd
Glass Developments, Ltd
Holiday & Hemmerdinger Ltd
Joyce, Loebl & Co Ltd
Kelvin & Hughes (Industrial) Ltd
Labgear Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Mullard Ltd
Nagard Ltd
Nuclear Enterprises (GB) Ltd
Plessey Nucleonics Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Siemens Edison Swan Ltd
Sunvic Controls Ltd

PRECIOUS METALS
★ Circle **No 791** on reply card
Baker Platinum Div, Engelhard Industries Ltd
General Chemical & Pharmaceutical Co Ltd, The
Johnson, Matthey & Co Ltd
Laboratory Apparatus & Glass Blowing Co
Mond Nickel Co Ltd, The
Sheffield Smelting Co Ltd, The

PRESCALERS
★ Circle **No 792** on reply card
Isotope Developments Ltd
Labgear Ltd
Lock & Co Ltd, A. M.
Panax Equipment Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd

PROBE UNITS—NUCLEONIC
★ Circle **No 793** on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Fleming Radio (Development) Ltd
General Radiological Ltd
Isotope Developments Ltd
Kelvin & Hughes (Industrial) Ltd
Labgear Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

PROBE QUENCH UNITS
★ Circle **No 794** on reply card
Burndept Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd

PUMPS—AIR
★ Circle **No 795** on reply card
Aerospray Associated Ltd
Alley & Maclellan Ltd
Baird & Tatlock (London) Ltd
Ben Patents Ltd
Broom & Wade Ltd
Chamberlain Industries Ltd
Clarke, Chapman & Co Ltd
Griffin & George Ltd
Holland Engineering Co Ltd, B. A.
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Wade Engineering Ltd
Weir Ltd, G. & J.
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS—COMBINED VACUUM & PRESSURE
★ Circle **No 796** on reply card
Alley & Maclellan Ltd
Baird & Tatlock (London) Ltd
Ben Patents Ltd
Broom & Wade Ltd
Capper Ltd, W.
Clarke, Chapman & Co Ltd
Cuthbert Ltd, Ralph
Edwards High Vacuum Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Ingersoll-Rand Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Mono Pumps Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Vacuum Industrial Applications Ltd
Wade Engineering Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

PUMPS—GAS BALLAST & BOOSTER
★ Circle **No 797** on reply card
Capper Ltd, W.
ECD Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Holland Engineering Co Ltd, B. A.
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Sigmund Pumps Ltd
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd

PUMPS—HIGH VACUUM, ION GETTER
★ Circle **No 798** on reply card
Edwards High Vacuum Ltd
Leybold Vacuum Sales Ltd
Fleischmann (London) Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

PUMPS—HIGH VACUUM, MERCURY DIFFUSION
★ Circle **No 799** on reply card
Cuthbert Ltd, Ralph
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Glass Developments Ltd
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Springham & Co, G. H.
Thermal Syndicate Ltd, The
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd

PUMPS—HIGH VACUUM, OIL DIFFUSION
★ Circle **No 800** on reply card
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Glass Developments Ltd
Griffin & George Ltd
Leland Instruments Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd

PUMPS—VACUUM, ROTARY
★ Circle **No 801** on reply card
Belliss & Morcom Ltd
Ben Patents Ltd
Calmic Engineering Co Ltd
Capper Ltd, W.
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Holland Engineering Co Ltd, B. A.
K.S.B. Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd
Mirrlees (Engineers) Ltd
Mono Pumps Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Reavell & Co Ltd
Sandall Precision Ltd
Stewart Aeronautical Ltd
Towers & Co Ltd, J. W.
Vacuum Industrial Applications Ltd
Western Detail Mfrs Ltd
Whittaker Hall & Co (1929) Ltd
Williams & James (Engineers) Ltd
Worthington-Simpson Ltd

PUMPS—WATER JET
★ Circle **No 802** on reply card
Edwards High Vacuum Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Leybold Vacuum Sales Ltd
Mono Pumps Ltd
QVF Ltd
Sealed Motor Construction Co Ltd
Towers & Co Ltd, J. W.
Western Detail Mfrs Ltd

PYROMETERS—OPTICAL
★ Circle **No 803** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Griffin & George Ltd

PYROMETERS—PHOTOELECTRIC
★ Circle **No 804** on reply card
AEW Ltd
Cambridge Instrument Co Ltd
Elcontrol Ltd
Foster Instrument Co Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
West Instruments Ltd

PYROMETERS—POTENTIOMETRIC
★ Circle **No 805** on reply card
AEW Ltd
Cambridge Instrument Co Ltd
Elliott Brothers (London) Ltd
Foster Instrument Co Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Negretti & Zambra Ltd
Shandon Scientific Co Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

PYROMETERS—RADIATION
★ Circle **No 806** on reply card
AEW Ltd
Baird & Tatlock (London) Ltd
British Thomson-Houston Co Ltd, The
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Honeywell-Brown Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Research & Control Instruments Ltd
Wykeham Ltd

PYROMETERS—RESISTANCE
★ Circle **No 807** on reply card
AEW Ltd
Bayley Clanahan Ltd
Cambridge Instrument Co Ltd
CNS Instruments Ltd
Cuthbert Ltd, Ralph
Elliott Bros (London) Ltd
Fielden Electronics Ltd
Foster Instrument Co Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
KDG Instruments Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George

PYROMETERS—RESISTANCE—*continued*
Lancashire Dynamo Electronic Products Ltd
Negretti & Zambra Ltd
Sangamo Weston Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

PYROMETERS—THERMO-ELECTRIC
★ Circle No 808 on reply card
AEW Ltd
Bayley Clanahan Ltd
Cambridge Instrument Co Ltd
Cuthbert Ltd, Ralph
Electrothermal Engineering Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Griffin & George Ltd
Honeywell-Brown Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Measuring Instruments (Pullin) Ltd
Negretti & Zambra Ltd
Spembly Ltd
Thermocontrol Installations Co Ltd
White Electrical Instrument Co Ltd
Wykeham Ltd

RACKS—CABINET
★ Circle No 809 on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Brown & Co Ltd, E. G.
Dynatron Radio Ltd
Ekco Electronics Ltd
Hutcheon Duthie & Sons Ltd, R.
Kimberley Engineering Ltd
Labgear Ltd
Microwave Instruments Ltd
Rediweld Ltd
Rubery Owen Ltd (Wrexham)
Southborough (Weybridge) Ltd
Vickers-Armstrongs (A/C) Ltd

RADIOGRAPHIC EQUIPMENT
★ Circle No 810 on reply card
Andrews, Cuthbert
Arc Mfg Co Ltd
Falk & Co Ltd, M.
Gamma-Rays Ltd
Gammax Ltd
General Electric Co Ltd
General Radiological Ltd
Ilford Ltd
Kodak Ltd
Marconi Instruments Ltd
Marine & Industrial Plastics Ltd
Metropolitan-Vickers Electrical Co Ltd
Mullard Equipment Ltd
Newton Victor Ltd
Pantak Ltd
Research & Control Instruments Ltd
Solus-Schall Ltd
Smith, R. F.
Welding Supplies Ltd

RADIOGRAPHY SERVICES (*See Section 1*)

RATEMETERS—FIELD
★ Circle No 811 on reply card
Elliott Brothers (London) Ltd
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nuclear Enterprises (GB) Ltd
Nucleonic & Radiological Developments Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—LABORATORY
★ Circle No 812 on reply card
Burndept Ltd
Cuthbert Ltd, Ralph
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Ekco Electronics Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—PORTABLE
★ Circle No 813 on reply card
Ericsson Telephones Ltd
Falk & Co Ltd, M.
Fleming Radio (Developments) Ltd
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Nuclear Enterprises (GB) Ltd
Nucleonic & Radiological Developments Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Research & Control Instruments Ltd

RATEMETERS—RECORDING
★ Circle No 814 on reply card
Falk & Co Ltd, M.
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Panax Equipment Ltd
Research & Control Instruments Ltd

REACTOR CONTROL SYSTEMS (*see Sec. 1*)

REACTORS—NUCLEAR RESEARCH
★ Circle No 815 on reply card
AEI—John Thompson Nuclear Energy Co Ltd (Merlin type)
Hawker Siddeley Nuclear Power Co Ltd (Jason type)
Head Wrightson Processes Ltd (Dido and Pluto types)
Miles Hivolt Ltd
Research & Control Instruments Ltd
Sheet Metal Engineering Ltd (agents for Curtiss-Wright)
Vickers-Armstrongs (A/C) Ltd

RECORDERS—ANNULAR CHART
★ Circle No 816 on reply card
Accurate Recording Instrument Co, The
Appleby & Ireland Ltd
British Rototherm Co Ltd, The
Cambridge Instrument Co Ltd
Elliott Brothers (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foxboro-Yoxall Ltd
Glass Developments Ltd
Gordon & Co Ltd, James
Hendrey Relays Ltd
Honeywell Controls Ltd
Isotope Developments Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
McKellen Automation Ltd
Record Electrical Co Ltd, The
Savage & Parsons Ltd
Southern Instruments, Computer Division
Sunvic Controls Ltd
Taylor-Short & Mason Ltd
Thermocontrol Installations Co Ltd

RECORDERS—POTENTIOMETRIC, STRIP CHART
★ Circle No 817 on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Foxboro Yoxall Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Mercer Ltd, T.
Pye & Co Ltd, W. G.
Research & Control Instruments Ltd
Stonebridge Electrical Co Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
Wykeham Ltd

RECORDERS—STRIP CHART, MULTI-POINT
★ Circle No 818 on reply card
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
Foster Instrument Co Ltd
Guest Industrials Ltd
Hendrey Relays Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
Kelvin & Hughes (Industrial) Ltd
Kent Ltd, George
Leland Instruments Ltd
Livingston Laboratories Ltd
McKellen Automation Ltd
Research & Control Instruments Ltd
Siemens Edison Swan Ltd
Sigma Instrument Co Ltd
Smiths Industrial Instruments Ltd
Sunvic Controls Ltd
Wykeham Ltd

RECTIFIERS—DRY PLATE
★ Circle No 819 on reply card
British Thomson-Houston Co Ltd, The
Electric Construction Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Hirst Electronic Ltd
Holiday & Hemmerdinger Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Standard Telephones & Cables Ltd
Texas Instruments Ltd
Westinghouse Brake & Signal Co Ltd

RECTIFIERS—MERCURY ARC
★ Circle No 820 on reply card
British Thomson-Houston Co Ltd, The
Electric Construction Co Ltd, The
English Electric Co Ltd, The
General Electric Co Ltd, The
Hackbridge & Hewittic Electric Co Ltd
Hirst Electronic Ltd
Newton Victor Ltd
Research & Control Instruments Ltd
Texas Instruments Ltd

RECTIFIERS—THERMIONIC
★ Circle No 821 on reply card
British Thomson-Houston Co Ltd, The
Ferranti Ltd
General Electric Co Ltd, The
General Radiological Ltd
Hirst Electronic Ltd
Holiday & Hemmerdinger Ltd
Lancashire Dynamo Electronic Products Ltd
Mullard Ltd
Research & Control Instruments Ltd
Standard Telephones & Cables Ltd
Texas Instruments Ltd

RELAYS—a.c.
★ Circle No 822 on reply card
A.D.S. Relays Ltd
ASEA Electric Ltd
Austinlite Ltd
Besson & Robinson Ltd
British Thomson-Houston Co Ltd
Chamberlain & Hookham Ltd
Cuthbert Ltd, Ralph
Donovan Electrical Co Ltd
Electric Construction Co Ltd, The
Electro Methods Ltd
Elliott Brothers (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Ferranti Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Isenthal & Co Ltd
Kent Ltd, George
Klöckner Moeller England Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Magnetic Devices Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Pye Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Rotax Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Simmonds Ltd, L. E.
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stewart Aeronautical Ltd
Stone Chance Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

RELAYS—d.c.
★ Circle No 823 on reply card
A.D.S. Relays Ltd
ASEA Electric Ltd
Austinlite Ltd
Besson & Robinson Ltd
British Thomson-Houston Co Ltd, The
Chamberlain & Hookham Ltd
Cuthbert Ltd, Ralph
Donovan Electrical Co Ltd
Electro Methods Ltd
Electronic Construction Co Ltd, The
Elliott Brothers (London) Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Ferranti Ltd
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Isenthal & Co Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Londex Ltd
Magnetic Devices Ltd
Measuring Instruments (Pullin) Ltd
Metropolitan-Vickers Electrical Co Ltd
Newmark Ltd
Plessey Nucleonics Ltd
Pullin & Co Ltd, R. B.
Pye Ltd
Record Electrical Co Ltd, The
Reyrolle & Co Ltd, A.
Rotax Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Simmonds Ltd, L. E.
Smiths Industrial Instruments Ltd
Standard Telephones & Cables Ltd
Stewart Aeronautical Ltd
Stone Chance Ltd
Sunvic Controls Ltd
West Instruments Ltd
White Electrical Instrument Co Ltd

RELAYS—ELECTRONIC
★ Circle No 824 on reply card
Allied Electronics Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Elcontrol Ltd
Electric Construction Co Ltd, The
Elliott Brothers (London) Ltd
Fielden Electronics Ltd
General Electric Co Ltd, The
Kent Ltd, George
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Magnetic Devices Ltd
Metropolitan-Vickers Electrical Co Ltd
Simmonds Ltd, L. E.
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

RELAYS—OIL PRESSURE
★ Circle No 825 on reply card
Ardleigh Engineering Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Gordon & Co Ltd, James
Ionic Instruments (London) Ltd
Klöckner Moeller England Ltd
Lancashire Dynamo Electronic Products Ltd
Londex Ltd
Metropolitan-Vickers Electrical Co Ltd
Monitor Patent Safety Devices Ltd
Nash & Thompson Ltd

RELAYS—TIME DELAY
★ Circle No 826 on reply card
A.D.S. Relays Ltd
Allied Electronics Ltd
ASEA Electric Ltd

RELAYS—TIME DELAY—*continued*
Austinlite Ltd
B. & K. Laboratories Ltd
Besson & Robinson Ltd
Boulton Paul Aircraft Ltd
British Thomson-Houston Co Ltd, The
Chamberlain & Hookham Ltd
Cuthbert Ltd Ralph
Elcontrol Ltd
Electrothermal Engineering Ltd
Electro Methods Ltd
English Electric Co Ltd, The
Geipel Ltd, William
General Electric Co Ltd, The
Hendrey Relays Ltd
Hirst Electronic Ltd
Isenthal & Co Ltd
Lancashire Dynamo Electronic Products Ltd
Lock & Co Ltd, A. M.
Londex Ltd
Metropolitan-Vickers Electrical Co Ltd
Nagard Ltd
Research & Control Instruments Ltd
Reyrolle & Co Ltd, A.
Rotax Ltd
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thermocontrol Installations Co Ltd

REMOTE HANDLING EQUIPMENT
(see Manipulators)

RESISTANCE TESTERS
★ Circle **No 827** on reply card
Avo Ltd
British Physical Laboratories
Cambridge Instrument Co Ltd
Doran Instrument Co Ltd
Electronic Instruments Ltd
Ekco Electronics Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Leland Instruments Ltd
Measuring Instruments (Pullin) Ltd
Muirhead & Co Ltd
Nash & Thompson Ltd
Pye Ltd
Record Electrical Co Ltd, The
Tinsley & Co Ltd, H.
White Electrical Instrument Co Ltd
Wykeham Ltd

RESISTORS—STANDARD & PRECISION
★ Circle **No 828** on reply card
AEW Ltd
Alto Instruments (GB) Ltd
B. & K. Laboratories Ltd
Cambridge Instrument Co Ltd
Doran Instrument Co Ltd
Dubilier Condenser Co (1925) Ltd
Electronic Instruments Ltd
Electrothermal Engineering Ltd
General Electric Co Ltd, The
Labgear Ltd
Leland Instruments Ltd
Lock & Co Ltd, A. M.
Lyons Ltd, Claude (agents for General Radio Co, USA)
Morgan Crucible Co Ltd, The
Muirhead & Co Ltd
Plessey Co Ltd, The
Pye Ltd
Salford Electrical Instruments Ltd
Stewart Aeronautical Ltd
Sullivan Ltd, H. W.
Technograph Ltd
Tinsley & Co Ltd, H.
Turner Ltd, E.
White Electrical Instrument Co Ltd

SAMPLE CHANGERS
★ Circle **No 829** on reply card
B. & K. Laboratories Ltd
Labgear Ltd
Research & Control Instruments Ltd
Vickers-Armstrongs (a/c) Ltd
Western Detail Mfrs Ltd

SAMPLE HOLDERS
★ Circle **No 830** on reply card
B. & K. Laboratories Ltd
Falk & Co Ltd, M.
Labgear Ltd
Vickers-Armstrongs (a/c) Ltd
Western Detail Mfrs Ltd

SCALERS
★ Circle **No 831** on reply card
Allied Electronics Ltd
B. & K. Laboratories Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Elliott Nucleonics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Isotope Developments Ltd
Labgear Ltd
Leland Instruments Ltd
Livingston Laboratories Ltd
Lock & Co Ltd, A. M.
Panax Equipment Ltd
Pye Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd
Sunvic Controls Ltd

SCINTILLATION COUNTERS
(see under Counters)

SCINTILLATORS—INORGANIC
★ Circle **No 832** on reply card
Ekco Electronics Ltd
Hilger & Watts Ltd
Isotope Developments Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd
Research & Control Instruments Ltd

SCINTILLATORS—LIQUID
★ Circle **No 833** on reply card
Ekco Electronics Ltd
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SCINTILLATORS—ORGANIC
★ Circle **No 834** on reply card
Hilger & Watts Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SCINTILLATORS—PLASTIC
★ Circle **No 835** on reply card
Isotope Developments Ltd
Lock & Co Ltd, A. M.
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd

SHIELDING
(see Sec 1, also Lead)

SIEVES—BRITISH STANDARD
★ Circle **No 836** on reply card
Baird & Tatlock (London) Ltd
Cuthbert Ltd, Ralph
Endecotts (Filters) Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
KC Productions Ltd
Laboratory Apparatus & Glass Blowing Co
Pascall Engineering Co Ltd, The
Springham & Co, G. H.
Towers & Co Ltd, J. W.

SIMULATORS—REACTOR
★ Circle **No 837** on reply card
Air Trainers Link Ltd
Elliott Nucleonics Ltd
Fairey Aviation Co Ltd, The
Hawker Siddeley Nuclear Power Co Ltd
Miles Hivolt Ltd
Pye Ltd
Solartron Electronic Group Ltd
Sunvic Controls Ltd
Vickers-Armstrongs (A/C) Ltd

SOLENOIDS
★ Circle **No 838** on reply card
British Thomson-Houston Co Ltd, The
Dowty Nucleonics Ltd
Electro-Hydraulics Ltd
Electro Methods Ltd
Hendrey Relays Ltd
Jones & Stevens Ltd
Lock & Co Ltd, A. M.
Phillips Control (GB) Ltd
Rotax Ltd
Stewart Aeronautical Ltd
Westool Ltd

SPECTROMETERS—GAMMA-RAY
★ Circle **No 839** on reply card
Dynatron Radio Ltd
Ekco Electronics Ltd
General Radiological Ltd
Isotope Developments Ltd
Nuclear Enterprises (GB) Ltd

SPECTROMETERS—INFRA-RED
★ Circle **No 840** on reply card
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Joyce, Loebl Ltd
Mervyn Instruments
Paton Hawksley Ltd
Pye Ltd.
Wykeham Ltd

SPECTROMETERS—MASS
★ Circle **No 841** on reply card
Elliott Bros Ltd
Metropolitan-Vickers Electrical Co Ltd
Vacuum Industrial Applications Ltd

SPECTROMETERS—NEUTRON DIFFRACTION
★ Circle **No 842** on reply card
Curran Ltd, John

SPECTROMETERS—ULTRAVIOLET
★ Circle **No 843** on reply card
Gallenkamp & Co Ltd, A.
Hilger & Watts Ltd
Joyce, Loebl & Co Ltd
Paton Hawksley Ltd
Pye Ltd

SPECTROMETERS—X-RAY
★ Circle **No 844** on reply card
Ekco Electronics Ltd
General Radiological Ltd
Hilger & Watts Ltd
Newton Victor Ltd
Paton Hawksley Ltd
Pye Ltd
Research & Control Instruments Ltd
Solartron Electronic Group Ltd
Solus-Schall Ltd

STATIC ELIMINATORS—NUCLEONIC
★ Circle **No 845** on reply card
Isotope Developments Ltd
Lock & Co Ltd, A. M.

SWITCHES—MICRO
★ Circle **No 846** on reply card
Armstrong Whitworth Aircraft Ltd
Burgess Products Co Ltd
Craig & Derricot Ltd
Honeywell Controls Ltd
Pye Ltd, Switch Division
Rotax Ltd
Stewart Aeronautical Ltd
Thermocontrol Installations Co Ltd

SURVEY INSTRUMENTS—NUCLEONIC
★ Circle **No 847** on reply card
Appleby & Ireland Ltd
Avo Ltd
Burndept Ltd
Dynatron Radio Ltd
Ekco Electronics Ltd
Ericsson Telephones Ltd
Falk & Co Ltd, M.
General Radiological Ltd
Hendrey Relays Ltd
Integra, Leeds & Northrup Ltd
Isotope Developments Ltd
Labgear Ltd
Nash & Thompson Ltd
Nuclear Enterprises (GB) Ltd
Panax Equipment Ltd
Plessey Nucleonics Ltd
Pye Ltd
Research & Control Instruments Ltd
Shandon Scientific Co Ltd
Siemens Edison Swan Ltd

SYNCHROS
★ Circle **No 848** on reply card
Appleby & Ireland Ltd
Austinlite Ltd
British Thomson-Houston Co Ltd, The
Elliott Bros (London) Ltd
Kent Ltd, George
Ketay Ltd
Muirhead & Co Ltd
Plessey Nucleonics Ltd
Pullin & Co Ltd, R. B.

TACHOMETERS
★ Circle **No 849** on reply card
Allied Electronics Ltd
Baird & Tatlock (London) Ltd
B. & K. Laboratories Ltd (electronic)
British Physical Laboratories
British Thomson-Houston Co Ltd, The
CNS Instruments Ltd
Electro Methods Ltd
Elliott Bros (London) Ltd
EMI Electronics Ltd
English Electric Co Ltd, The
Ericsson Telephones Ltd
Evershed & Vignoles Ltd
Guest Industrials Ltd
General Electric Co Ltd, The
Honeywell Controls Ltd
Ketay Ltd
Labgear Ltd
Lancashire Dynamo Electronic Products Ltd
Leland Instruments Ltd
Pullin & Co Ltd, R. B.
Racal Engineering Ltd
Record Electrical Co Ltd, The
Revo Electric Ltd
Salford Electrical Instruments Ltd
Sangamo Weston Ltd
Shandon Scientific Co Ltd
Smiths Industrial Instruments Ltd
Stewart Aeronautical Ltd

TANKS—ZINC BROMIDE WINDOW
★ Circle **No 850** on reply card
Evans & Son (Portsmouth) Ltd, J.
Harris (Birmingham) Ltd, F. & R. M.
Laboratory Apparatus & Glass Blowing Co
Marine & Industrial Plastics Ltd
Mendip (Chemical Engineering) Ltd
Power-Gas Corporation Ltd
QVF Ltd

TELEMETERING SYSTEMS
★ Circle **No 851** on reply card
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
Bailey Meters & Controls Ltd
Burndept Ltd
Cheltenham Auto Controls Ltd
Electronic Instruments Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
EMI Electronics Ltd
Evershed & Vignoles Ltd
Fielden Electronics Ltd
Foxboro Yoxall Ltd
General Electric Co Ltd, The
Integra, Leeds & Northrup Ltd
Honeywell Controls Ltd
Kent Ltd, George
Lancashire Dynamo Electronic Products Ltd
Muirhead & Co Ltd
Nuclear Engineering Ltd
Parkinson & Cowan Ltd
Pye Ltd
Rank Cintel Ltd
Rotameter Mfg Ltd
Salford Electrical Instruments Ltd
Southern Instruments (Computer Division)
Standard Telephones & Cables Ltd
Sunvic Controls Ltd
Thompson Ltd, J. Langham
Venner Ltd
Vernon Instruments Ltd
Weyers Bros Ltd
Winston Electronics Ltd
Wykeham Ltd

TELESCOPES—INDUSTRIAL & LABORATORY
★ Circle **No 852** on reply card
Avimo Ltd
Baker of London, Ltd, C.
Hilger & Watts Ltd
Precision Tool & Instrument Ltd
Ross Ensign Ltd

TELEVISION—INDUSTRIAL
★ Circle **No 853** on reply card
Armstrong Whitworth Aircraft Ltd, Sir W. G.
B. & K. Laboratories Ltd
EMI Electronics Ltd
Lancashire Dynamo Electronic Products Ltd
Livingston Laboratories Ltd
Marconi's Wireless Telegraph Co Ltd
Pye Ltd
Rank Cintel Ltd
Research & Control Instruments Ltd

THERMOCOUPLES
★ Circle **No 854** on reply card
Baker Platinum Div, Engelhard Industries Ltd
Bayley Clanahan Ltd

THERMOCOUPLES—*continued*
Cambridge Instrument Co Ltd
Electrothermal Engineering Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Fleischmann (London) Ltd
Foster Instrument Co Ltd
General Electric Co Ltd, The
Hilger & Watts Ltd
Honeywell Controls Ltd
Integra, Leeds & Northrup Ltd
KDG Instruments Ltd
Kelvin & Hughes Ltd
Kent Ltd, George
Johnson, Matthey & Co Ltd
Kidde Co Ltd, The Walter
Lock & Co Ltd, A. M.
Research & Control Instruments Ltd
Sangamo Weston Ltd
Sheffield Smelting Co Ltd
Spembly Ltd
Standard Telephones & Cables Ltd
Technograph Ltd
Thermocontrol Installations Co Ltd
Towers & Co Ltd, J. W.
Turner Ltd, E.
West Instruments Ltd
White Electrical Instrument Co Ltd

TITRATION APPARATUS
★ Circle **No 855** on reply card
Baird & Tatlock (London) Ltd
Cambridge Instrument Co Ltd
Doran Instrument Co Ltd
Gallenkamp & Co Ltd, A.
Griffin & George Ltd
Lock & Co Ltd, A. M.
Loughborough Glass Co Ltd
Research & Control Instruments Ltd
Shandon Scientific Co Ltd
Towers & Co Ltd, J. W.

TONGS—REMOTE HANDLING
(see Manipulators)

TOOLS—HAND
★ Circle **No 856** on reply card
Abingdon King Dick
Allen & Co Ltd, Edgar
Bayley Clanahan Ltd (fine grinding)
Bridges & Co Ltd, S. N.
Brooke Tool Ltd
BSA Tools Ltd
Carter & Viner
General Radiological Ltd
HL Instruments Ltd
Ingersoll-Rand Ltd (pneumatic)
Jessop & Sons Ltd, William
Lorant & Co Ltd
Moss & Gamble Bros Ltd
Osborn & Co Ltd, Samuel
Palatine Tool & Engineering Co (Surbiton) Ltd
Savage & Parsons Ltd
Wilkinsons Tools Ltd
Wolf Electric Tools Ltd

TRANSDUCERS
★ Circle **No 857** on reply card
Allied Electronics Ltd
Appleby & Ireland Ltd
Armstrong Whitworth Aircraft Ltd, Sir W. G.
B & K Laboratories Ltd
Barnet Instruments Ltd
Boulton Paul Aircraft Ltd
Cambridge Instrument Co Ltd
Cawkell Research & Electronics Ltd
Elliott Bros (London) Ltd
Elliott Nucleonics Ltd
Evershed & Vignoles Ltd
General Electric Co Ltd, The
Glass Developments Ltd
Hirst Electronic Ltd
KDG Instruments Ltd
Lock & Co Ltd, A. M.
Mullard Ltd (Ultrasonic)
New Electronic Products Ltd
Newmark Ltd
Racal Engineering Ltd
Research & Control Instruments Ltd
Salford Electrical Instruments Ltd
Shandon Scientific Co Ltd
Solartron Electronic Group Ltd
Solex (Gauges) Ltd
Southern Instruments, Computer Division
Sullivan Ltd, H. W.
Sunvic Controls Ltd
Technical Ceramics Ltd
Texas Instruments Ltd
Weyers Bros Ltd

TRANSISTORS
★ Circle **No 858** on reply card
B & K Laboratories Ltd
British Thomson-Houston Co Ltd, The
General Electric Co Ltd, The
English Electric Valve Co Ltd
Ferranti Ltd
Holiday & Hemmerdinger Ltd
Leland Instruments Ltd
Mullard Ltd
Pye Ltd
Newmarket Transistors Ltd
Salford Electrical Instruments Ltd
Semiconductors Ltd
Siemens Edison Swan Ltd
Standard Telephones & Cables Ltd
Solartron Electronic Group Ltd
Texas Instruments Ltd
Wykeham Ltd

VACUUM EQUIPMENT
★ Circle **No 859** on reply card
Ayling Nuclear Equipment Co
Barlow-Whitney Ltd
Bayley Clanahan Ltd (furnaces)
Blundell & Crompton Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
General Radiological Ltd
Leybold Vacuum Sales Ltd
Metropolitan-Vickers Electrical Co Ltd, The
NGN Electrical Ltd
Pulsometer Engineering Co Ltd, The
Shandon Scientific Co Ltd
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Vacuum Research (Cambridge) Ltd
Western Detail Mfrs Ltd
Worthington-Simpson Ltd

VACUUM GAUGES *(see Gauges)*

VACUUM PUMPS *(See Pumps)*

VACUUM TEST EQUIPMENT
★ Circle **No 860** on reply card
Barnet Instruments Ltd
Birch & Co Ltd. H. A.
Edwards High Vacuum Ltd
Elliott Bros (London) Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Northey Rotary Compressors Ltd
Pulsometer Engineering Co Ltd, The
Sunvic Controls Ltd
Vacuum Industrial Applications Ltd

VACUUM TUBING
★ Circle **No 861** on reply card
Blundell & Crompton Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
Gallenkamp & Co Ltd, A.
General Radiological Ltd
Glass Developments Ltd
Laboratory Apparatus & Glass Blowing Co
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Power Auxiliaries Ltd
Pulsometer Engineering Co Ltd, The
Vacuum Industrial Applications Ltd
Whitby & Chandler Ltd

VACUUM VALVES
★ Circle **No 862** on reply card
Appleby & Ireland Ltd
BEN Patents Ltd
Blundell & Crompton Ltd
British Steam Specialties Ltd
Edwards High Vacuum Ltd
Fleischmann (London) Ltd
General Electric Co Ltd, The
General Radiological Ltd
Hindle & Sons Ltd, Joshua
Holiday & Hemmerdinger Ltd
Inness & Co (Darlington) Ltd
IV Pressure Controllers Ltd
K.S.B. Ltd
Lacy-Hulbert & Co Ltd
Leybold Vacuum Sales Ltd
NGN Electrical Ltd
Palatine Tool & Engineering Co (Surbiton) Ltd
Pulsometer Engineering Co Ltd, The
T.A.L. Numatics Ltd
Vacuum Industrial Applications Ltd
Weir Valves Ltd
Western Detail Mfrs Ltd

COMPANY ADDRESSES

ABBOFLEX LTD, Abboflex Works, Walnut Tree Close, Guildford, Surrey *tel:* Guildford 5893
ABINGDON KING DICK, King's Rd, Birmingham, 11 *tel:* Acocks Green 2881
ABRASIVE DEVELOPMENTS LTD, 17 High St, Henley-in-Arden, Nr Solihull, Warwicks *tel:* Henley-in-Arden 160
ABRIL CORPORATION (GT BRITAIN) LTD, Golden Mile Works, Bridgend, Glam *tel:* Bridgend 821
ACALOR (1948) LTD, Kelvin Way, Crawley, Sussex *tel:* Crawley 1571
ACCLES & POLLOCK LTD, Oldbury, Birmingham *tel:* Broadwell 1500
ACCURATE RECORDING INSTRUMENT CO (ARIC LTD), THE Windsor Ave, Merton, S.W.19 *tel:* Liberty 5661-63
ACETYLENE GENERATOR & TOOL CO LTD, 27 Howland St, London, W1 *tel:* Museum 4435
ACHESON COLLOIDS LTD, Prince Rock, Plymouth *tel:* Plymouth 66351
ACM ELECTRONICS LTD, 61 Osborne Rd, Acton, W3 *tel:* Acorn 6931
ADAM MACHINE EQUIPMENT LTD, 4 Grange St, St Albans, Herts *tel:* St Albans 56731
ADAMSON, DANIEL, & CO LTD, Dukinfield, Ches *tel:* Ashton-under-Lyne 2822
ADCOCK & SHIPLEY LTD, PO Box 22, Ash St, Leicester *tel:* Leicester 24154
ADCOLA PRODUCTS LTD, Gauden Rd, Clapham, London, SW4 *tel:* Macaulay 3101
A.D.S. RELAYS LTD, 89-97 St John St, EC1 *tel:* Clerkenwell 3393
ADVANCE COMPONENTS LTD, Roebuck Rd, Hainault, Essex *tel:* Hainault 4444
AEI-JOHN THOMPSON NUCLEAR ENERGY CO LTD, 33 Grosvenor Place, SW1 *tel:* Belgravia 7011
AEI LAMPS AND LIGHTING CO LTD, Melton Rd, Leicester *tel:* Leicester 61531
AERASPRAY ASSOCIATED LTD, 179/213 Thimble Mill La, Birmingham, 7 *tel:* East 1671
AEROX LTD, Lister Place, Hillington Industrial Estate, Glasgow, SW2 *tel:* Halfway 4615
AEW LTD, Imperial Works High St, Edgware, Middx *tel:* Edgware 5278
AIMER PRODUCTS LTD, 56 Rochester Place, London, NW1 *tel:* Gulliver 3618
AIR CONDITIONING CORPORATION (JEFFREYS) LTD, St George's Ho, Waterloo Rd, London, SE1 *tel:* Waterloo 4433
AIR CONTROL INSTALLATIONS LTD, Ruislip, Middlesex *tel:* Ruislip 4066
AIR INDUSTRIAL DEVELOPMENTS LTD, Aidspray Works, Shenstone, Nr Lichfield, Staffs *tel:* Shenstone 341-5
AIR PUMPS LTD, Bushey Rd, Raynes Park, SW20 *tel:* Wimbledon 9441/6
AIR TRAINERS LINK LTD, Bicester Rd, Aylesbury, Bucks *tel:* Aylesbury 4611
AIRCRAFT ENGINEERING & JIGS LTD, Hargreaves Wks, Oldham, Lancs *tel:* Main (Oldham) 3818
AIRCRAFT - MARINE PRODUCTS (GREAT BRITAIN) LTD, 60 Kingsley St, London, W1 *tel:* Regent 2517
AIRMEC LTD, Coronation Rd, High Wycombe, Bucks *tel:* High Wycombe 2060
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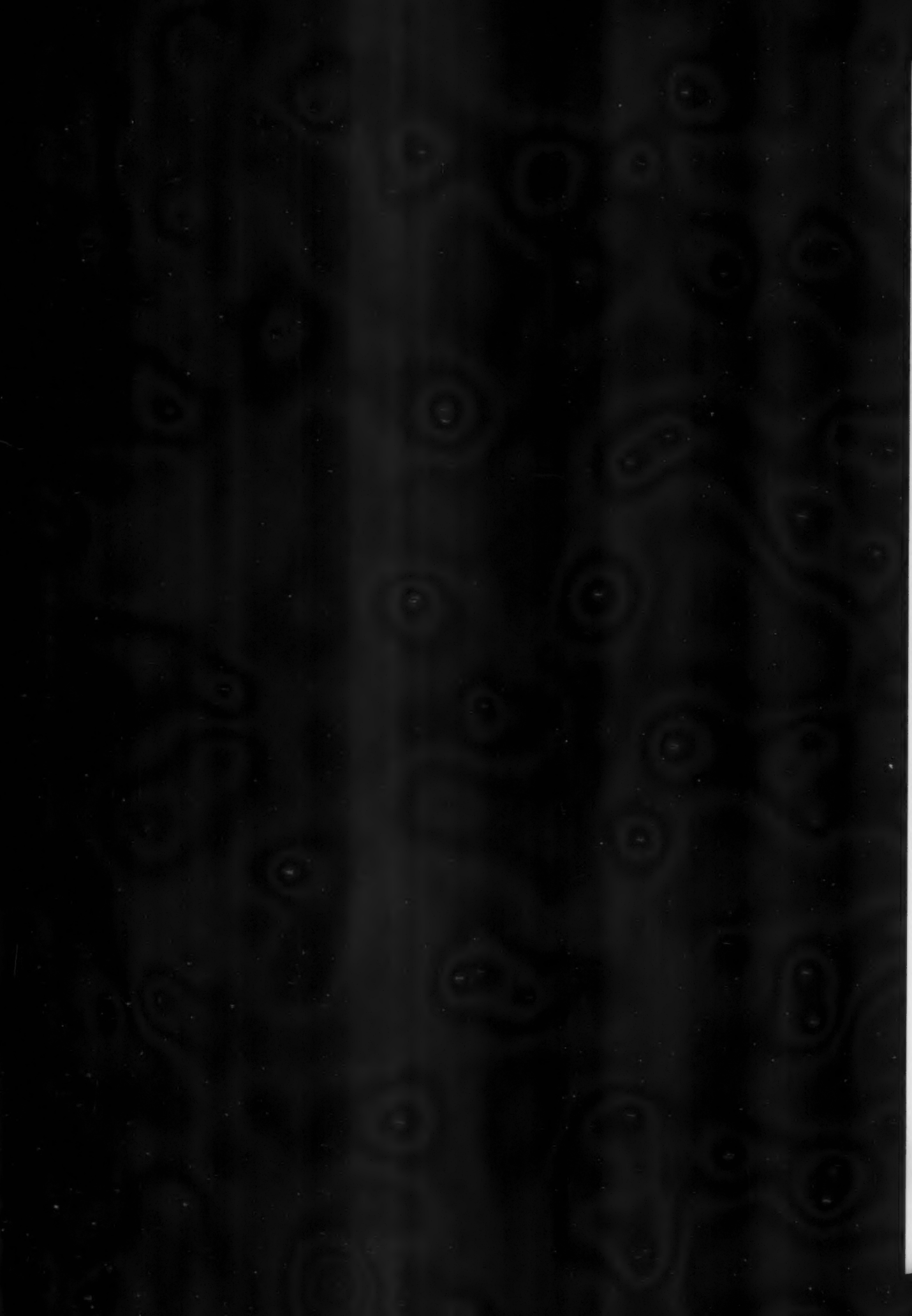

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